Appendix I

Conceptual Design and Cost Estimate

Appendix J

Conceptual Design and Cost Estimate

Introduction

This appendix presents an innovative conceptual approach to retrieving waste buried in transuranic pits and trenches at the Idaho National Engineering and Environmental Laboratory (INEEL) Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA). In addition, the appendix gives a rough-order-of-magnitude cost estimate for applying the design in the SDA transuranic pits and trenches. The overall concept is to first grout the buried transuranic waste using the INEEL jet-grouting process to form a monolith, then retrieve the monolith, taking advantage of the agglomeration of contaminants caused by grouting.

Efforts in the 1970s to retrieve transuranic waste focused on contamination control problems as the most challenging aspect of the retrieval effort. These retrieval efforts included the early waste retrieval (EWR) in SDA Pits 1, 2, and 3,[1] and the initial drum retrieval (IDR) effort at SDA Pits 11 and 12.[2]

The EWR project used an archeological approach to retrieval using a small backhoe and personnel were in totally enclosed bubble suits. Many examples of plutonium spread were encountered and only hundreds of drums were removed.

The IDR project retrieved recently interred drums without spreading airborne contamination within a weather shield. During the IDR project, a backhoe was used to probe SDA Pits 6, 9, and 10 for possible applications of the open-air IDR technology. However, the plutonium/americium contamination on the backhoe was too high (up to E6 counts per minute) to effectively retrieve the waste with the open-air IDR approach.

During the late 1980s, a Pit-9 retrieval project was planned, and a preliminary design was produced that involved full-pit retrieval using double containment retrieval enclosures, remote operation of a variety of large excavating equipment, and an elaborate contamination control strategy.[3] The project involved retrieving and packaging the waste and storing the waste in Resource Conservation and Recovery Act (RCRA)-approved containment buildings. The project was stopped when the SDA transuranic pits and trenches were placed on the National Priorities List as part of the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA) which demanded examining a wide variety of technologies prior to applying retrieval as the remediation of choice.

During the 1990s, a series of transuranic waste retrieval projects was examined as developmental research under the Department of Energy Technology Development program. Both conventional and innovative transuranic waste retrieval concepts were examined, including basic retrieval with heavy equipment,[4] cryogenic retrieval (freezing the waste, followed by remote retrieval),[5] and direct remote retrieval.[6] Following a series of studies to determine the spread of contamination, it was concluded that conventional retrieval of waste containing finely divided plutonium and dry INEEL soils would be very difficult.[7,8,9] The concept of applying cryogenic freezing of the waste followed by retrieval was highly effective, but the cost and complexity of freezing the waste was a drawback. Grouting the waste followed by retrieval was a technology similar to the cryogenic approach; however, the grouting process simulated the agglomeration provided by the freezing process without the complexity of freezing the waste. With this new concept, the innovative grout/retrieval technology was tested as a Technology Development project using ordinary Portland cement as the grouting agent with a positive proof of concept.[10]

Subsequent studies of grout followed by retrieval, using other grouting agents, including acrylic polymer[11] and a paraffin material called WaxFix.[12] During retrieval of a test pit injected with molten Waxfix, observations confirmed that the molten wax had an acceptable degree of penetration into the waste, thus providing extraordinary agglomeration of contaminants and allowing easy retrieval. Because of the positive proof-of-concept, this technology is currently part of INEEL Waste Area Group 7-13/14 CERCLA Treatability Study.[13]

This engineering design file offers a conceptual design of the grouting/retrieval process as a basis for a rough order of magnitude cost estimate. The conceptual design starts with a list of major programmatic assumptions, the main assumption being that full-pit retrieval will be followed by processing for "retrievable disposal" or, alternatively, interim storage. The design assumes that the retrieved and repackaged waste will be treated with a nonthermal encapsulation process and then re-deposited in the original pit or, trench or as an alternative, placed in RCRA-approved storage. This engineering design file estimates the cost for a CERCLA treatability study on a small portion of a transuranic pit or trench and for retrieval of material in WAG 7 13/14 transuranic pits and trenches at the RWMC SDA.

Preconceptual Design

Five distinct phases comprise the grout/retrieval/disposal process, which follows a complete "cradle-to-grave" approach with no deferred decisions on final disposition of the waste. The first phase is site preparation; the second phase is the grouting process; the third phase is retrieval and packaging for transportation to an accumulation area; the fourth stage is transportation and processing at an encapsulation plant; and the fifth stage is reburial of the processed waste with improved confinement in the pits and trenches from which it was removed or optionally placed in interim, above-ground, RCRA storage. Because this process has never been applied, assumptions must be made to anticipate unknown factors in the process. For instance, the process assumes a final logical disposal site for the waste. This approach would require discussion with state of Idaho and local interests groups; however, the concept eliminates interstate agreements which are proving difficult if not impossible to effect.

Furthermore, this preconceptual design eliminates the need to segregate the waste into transuranic waste; transuranic-contaminated, low-level waste; alpha mixed low-level waste; hazardous waste, and clean soil. Rather, all of the waste is treated as one class—retrieved transuranic pit or trench waste. By eliminating segregation, the need for technically questionable assay systems is also eliminated. The assay of heterogeneous retrieved waste may not be possible at any cost. A cost savings from waste minimization would be trivialized by the cost of an assay system that could measure heterogeneous waste within ±1 nCi/g.

The overall concept of this process eliminates, to the extent possible, deferred or assumed solutions for the final waste material. The retrieval and treatment process requires identification of realistic final disposal options before completing the design. The design, in turn, accommodates the chosen paths for the waste. Therefore, the conceptual designs offered in this engineering design file make reasonable assumptions for the final disposition of the waste (i.e., the waste will go to a specific site rather than an undetermined offsite disposal site). An additional guiding principle is that the waste will be removed and, to the extent possible, repackaged in an improved form (such as, encapsulated in polyethylene) that is suitable for reburial in the very site from which it was removed. Any retrieval and reburial process of the transuranic waste will require innovative negotiations among interested parties and possible exemptions from portions of existing environmental laws. Exact adherence to all laws could preclude accomplishing remediation of transuranic pits and trenches; therefore the preconceptual design offered here obviously is contradicting to some existing laws.

Programmatic Assumptions

Major assumptions for the grout/retrieval/disposal process are:

- The project will be conducted in two steps: (1) a treatability study involving processing a 1-acre pit, and (2) remediation of 9 acres of transuranic pits, using equipment from the treatability study.
- The design will support a 7-year retrieval and reburial (retrievable disposal) in nine acres of the transuranic pits and trenches at the INEEL SDA.
- CERCLA and RCRA will apply to the extent possible, and any deviations or exemptions will be agreed upon by interested parties. In addition, the initial full-pit retrieval will be performed under an interim Record of Decision.
- All of the retrieved and encapsulated waste will be placed in shallow land burial within the pit from which it came. The treated waste can be retrieved in the future for other considerations, if required. As an option, the retrieved and encapsulated waste can be placed in interim RCRA storage rather than "retrievable disposal."
- The entire quantity of retrieved stored waste will be encapsulated with advanced encapsulation schemes involving further size reduction and polyethylene mixing.
- No assay of the waste will be performed, other than that necessary to control contamination spread during the entire process; rather, the waste will be treated as a special case: retrieved buried transuranic waste for processing and reburial.
- The process will require further size reduction prior to encapsulation with off-the-shelf devices.
- Following use, the weather shield complex will only be slightly contaminated and can be buried in one of the last pits excavated as low-level waste.

Design Features

Major design features are site preparation, grouting, retrieval, accumulation area, encapsulation area, and finally either retrievable disposal or interim storage. Each of these features is presented below.

Site Preparation

Site preparation includes preparing the top surface of the pit and placing temporary movable weather shields and ancillary adjacent buildings for the grout/retrieval campaign.

The top surface of the site will be leveled to ±2 ft over the entire pit, with the assumption that the top 2 ft overburden is clean soil. This soil will be stockpiled within the weather shield to be used in the grouting process as a berming material. Next a series of three adjacent temporary structures will be erected over the pit. One of the structures is assumed to be a SPRUNG structure (approximately 168 × 400 ft) connected to two packaging/decontamination/transition buildings (approximately 50 × 50 ft). All buildings will have a slight negative pressure and air flow will be filtered by high-efficiency particulate air (HEPA) filtration systems as shown in Figure 1.

Grouting Phase

Grouting equipment will be placed in the building covering the pit. This equipment will consist of a movable, lightweight, remotely-operated platform (like an x-y positional system) fitted with a drilling apparatus equivalent to a CASA GRANDE C-6 or C-8. The platform will be placed on a bermed area covering about 400 ft^2 (20 × 20 ft) of the pit. Drilling equipment on the platform will include the hydraulic equipment and drill mast but not the transport tracks and motor. A separate hydraulic motor will be assembled in the weather shield from which grouting will be monitored.

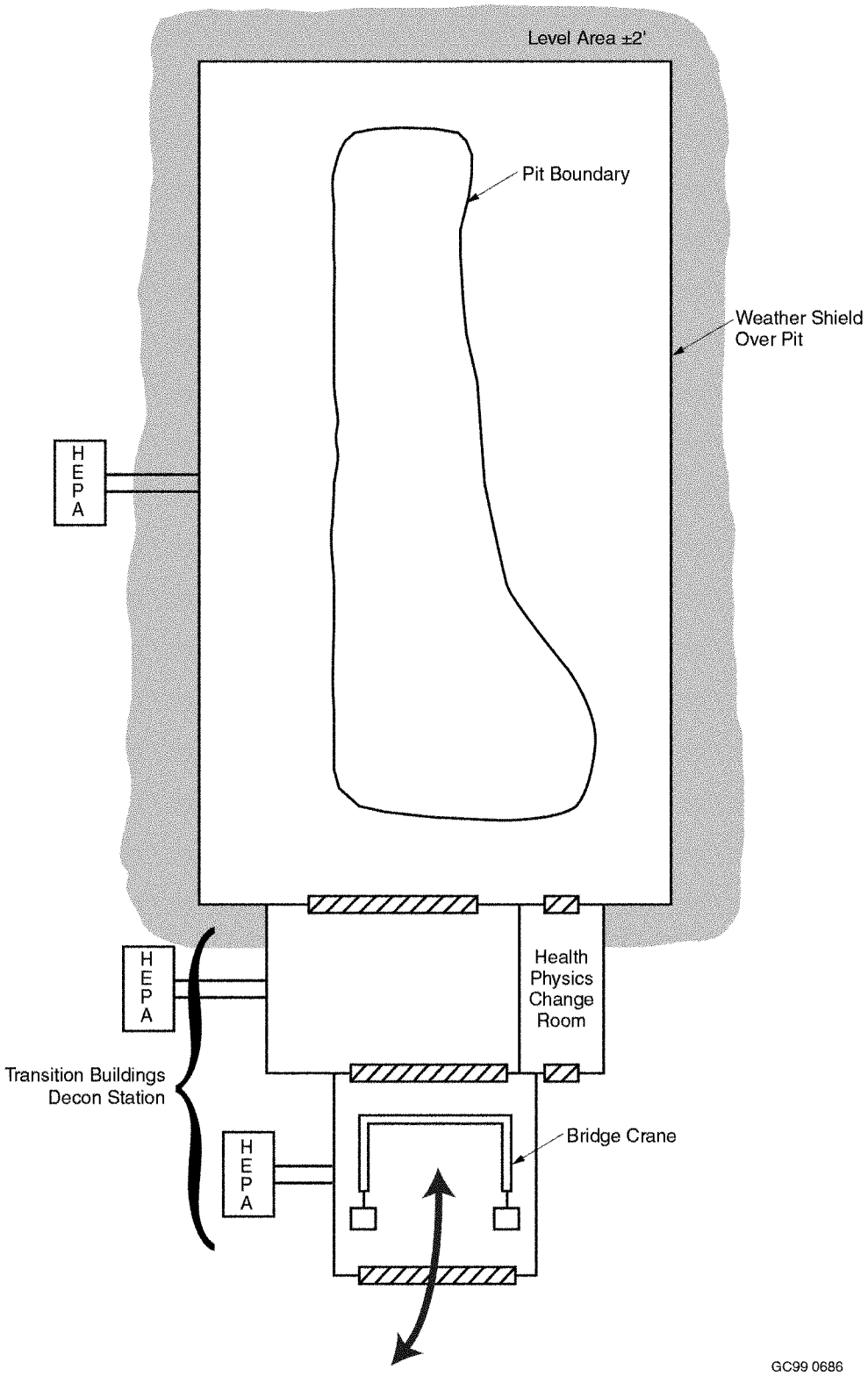

Figure 1. Buildings will have a slight negative pressure, and air flow will be cleaned by HEPA filters.

On a predetermined grid pattern, molten Waxfix (including 1g/L of boron to eliminate criticality concerns) will be injected into the waste. From past experience,[12] copious grout returns are anticipated within the confines of the bermed area that will form a reservoir of molten Waxfix. Once the area under the platform has been completely grouted, the platform will be moved by forklift to a new position. By continuing this process, an acre-sized pit can be grouted in a 2-year period, working one shift. Figure 2 shows the overall grouting process with tanker truck access for the delivery of the molten paraffin.

Retrieval Phase

In the conceptual design, the retrieval phase is performed after the entire pit has been grouted. There is an option for the retrieval operation to start after the pit is about half grouted and the delivery of paraffin can be accomplished via side or opposite end access. The retrieval operation requires a sealed, positive pressure cab, heavy excavation equipment, including a large front-end loader/backhoe with Baldersom thumb, a heavy duty fork lift, and a large track mounted shear. The fixation of aerosolizable particulate caused by the Waxfix grouting allows a "sealed cab" approach.

The retrieval will be performed from the bottom via an access ramp as shown in Figure 3. Waste will be retrieved and partially sized at the dig face. There will be no dig face diagnostics; rather, the retrieval equipment will be chosen to accommodate the largest objects buried in the pits. Intact, large, metal vaults will be sized at the dig face, as will large tanks and even vehicle bodies, if encountered. The presized materials will be focused through a funnel into a series of disposable polyethylene $4 \times 4 \times 8$ ft boxes. Reusable contamination control mats will be placed adjacent to the dig face and the heavy equipment and forklift will be operated on these mats. Mats will be added as the dig face is advanced. Objects that cannot be size reduced at the dig face will be evaluated for beta gamma activity and may be declared special case low-level waste material that will be left in the pit. In special cases, the object will be manipulated to the side of the pit such that further retrieval is not impeded.

The fork lift will be used to remove the boxes from the dig face to the packaging/decontamination area in the adjoining building. In the packaging area, a shrink wrap will be applied in duplicate to the transporter box and then the boxes will be placed on a semi-tractor open trailer system for transporting to the accumulation storage building and eventually to the encapsulation facility.

Accumulation Area

A RCRA-approved interim (surge) storage accumulation area will be provided for a lag between the retrieval and the encapsulation phase of the operation (see Figure 4). This surge storage is necessary because the retrieval rate of waste may be faster than the encapsulation rate. Also in the event of an extended shutdown to repair retrieval equipment, the storage will be weather protected until the encapsulation facility can process the inventory. The surge storage building design will be similar to the transuranic waste storage building currently used at the RWMC.

Encapsulation Phase

The encapsulation phase, if used, improves the confinement of the retrieved waste by size reduction and then encapsulation of the waste with low-melting temperature polyethylene durability. A schematic of this process is shown in Figure 5. The size reduction and encapsulation processes are based on developmental research sponsored by the DOE Environmental Management Technology Development.[14]

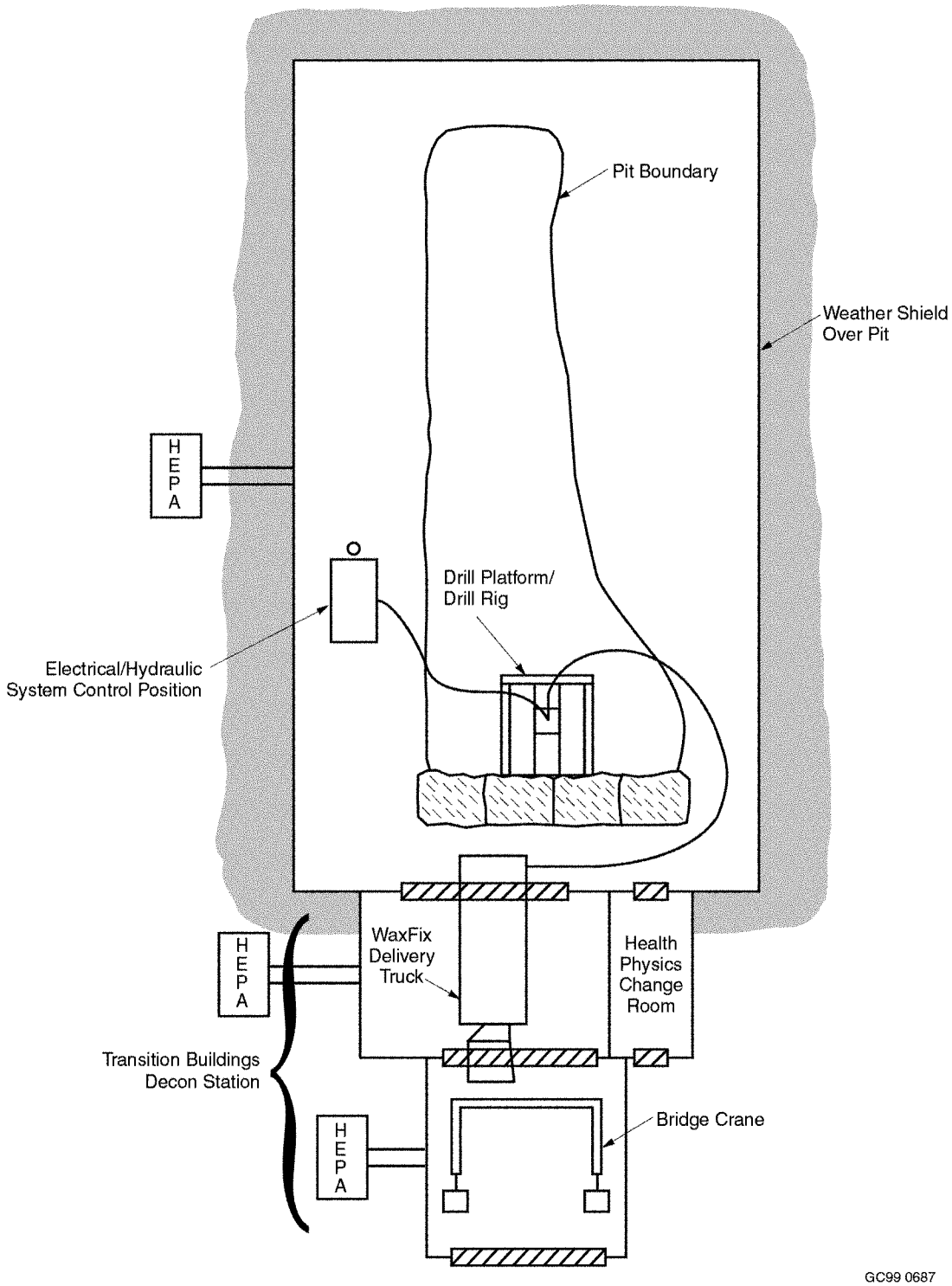

Figure 2. Overall grouting process with tanker truck access for the delivery of the molten paraffin.

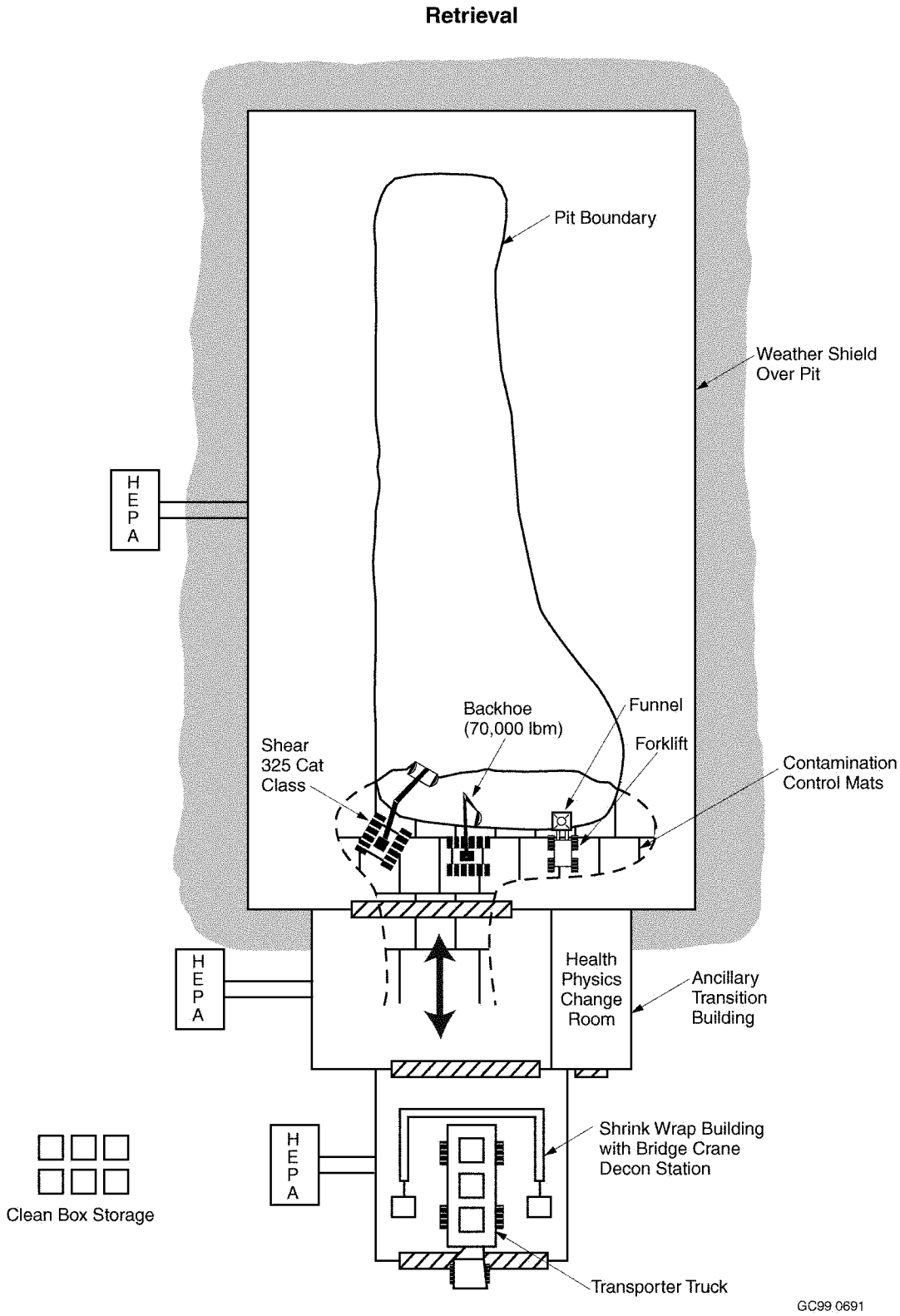

Figure 3. Retrieval will be performed from the bottom via an access ramp.

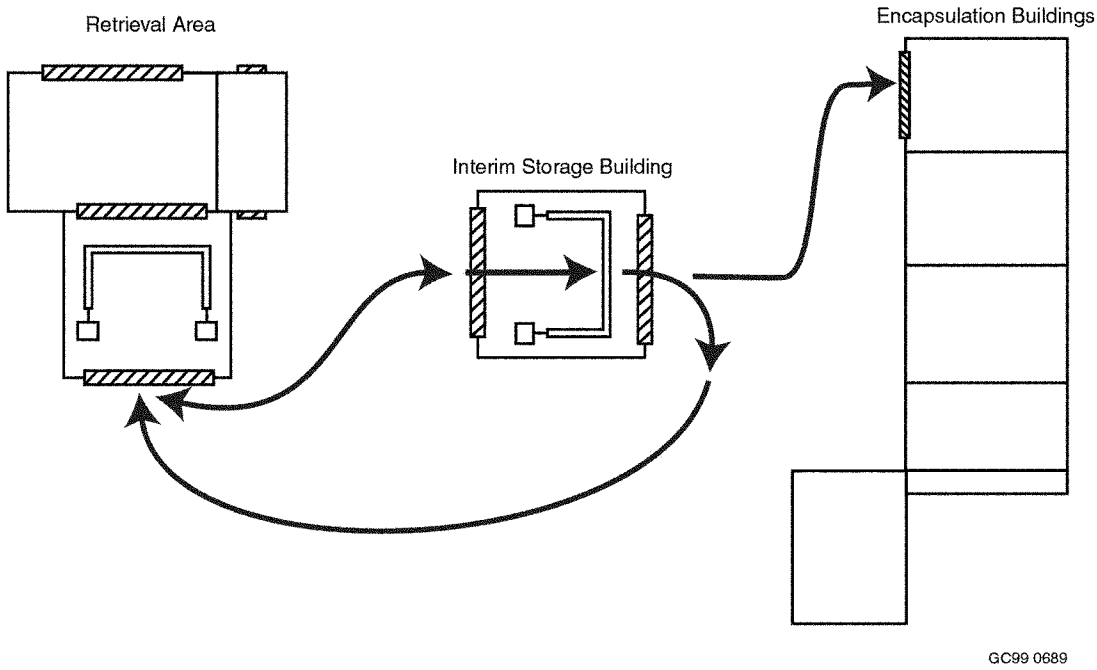

Figure 4. Accumulation area will be provided for a lag between retrieval and encapsulation phases.

The size reduction will involve the CRYOFRACTURE system, which is essentially fire and explosion proof. The CRYOFRACTURE system involves freezing the retrieved waste to liquid nitrogen temperatures, then fracturing the brittle waste with a 1,000-ton press, which has a special attachment for cutting stainless steel items. This loose, frozen, sized material (90% will be 3 in. or less) will then be sent to a heater room by a V-belt conveyor. Once at room temperature, the waste will be sent to a mixing room and blended with low-melt temperature (180°F) polyethylene. Once the CRYOFRACTURED waste is blended with the polyethylene material, it is extruded into final waste forms using 4 × 4 × 8-ft molded polyethylene boxes with lids. These boxes have built-in lifting lugs for ease in transport to the disposal facility. The waste form will be designed such that the waste is both micro- and macro-encapsulated. Polyethylene encapsulation technologies have shown that the waste form is extremely durable for possible geologic times.

All of the technologies used in this process (paraffin grout, CRYOFRACTURE for size reduction, and encapsulation in polymers) have inherent contamination control features. Combining the technologies guarantees essentially no spread of contamination throughout the process.

Retrievable Disposal or Interim Storage

Retrievable disposal means that the waste forms while permanently disposed of can easily be removed for transportation to another treatment facility or offsite disposal facility at a later date. Figure 6 shows the final disposal option, in which the retrieved pit is sealed under the weather shield and surrounded with approximately 6-ft-thick concrete bottom and side walls (fully plasticized—low heat of hydration aggregate concrete). Once the concrete walls and bottom are constructed, the weather shield and ancillary buildings are internally sprayed with strippable paint, dismantled, and set up on a different pit to repeat the process.

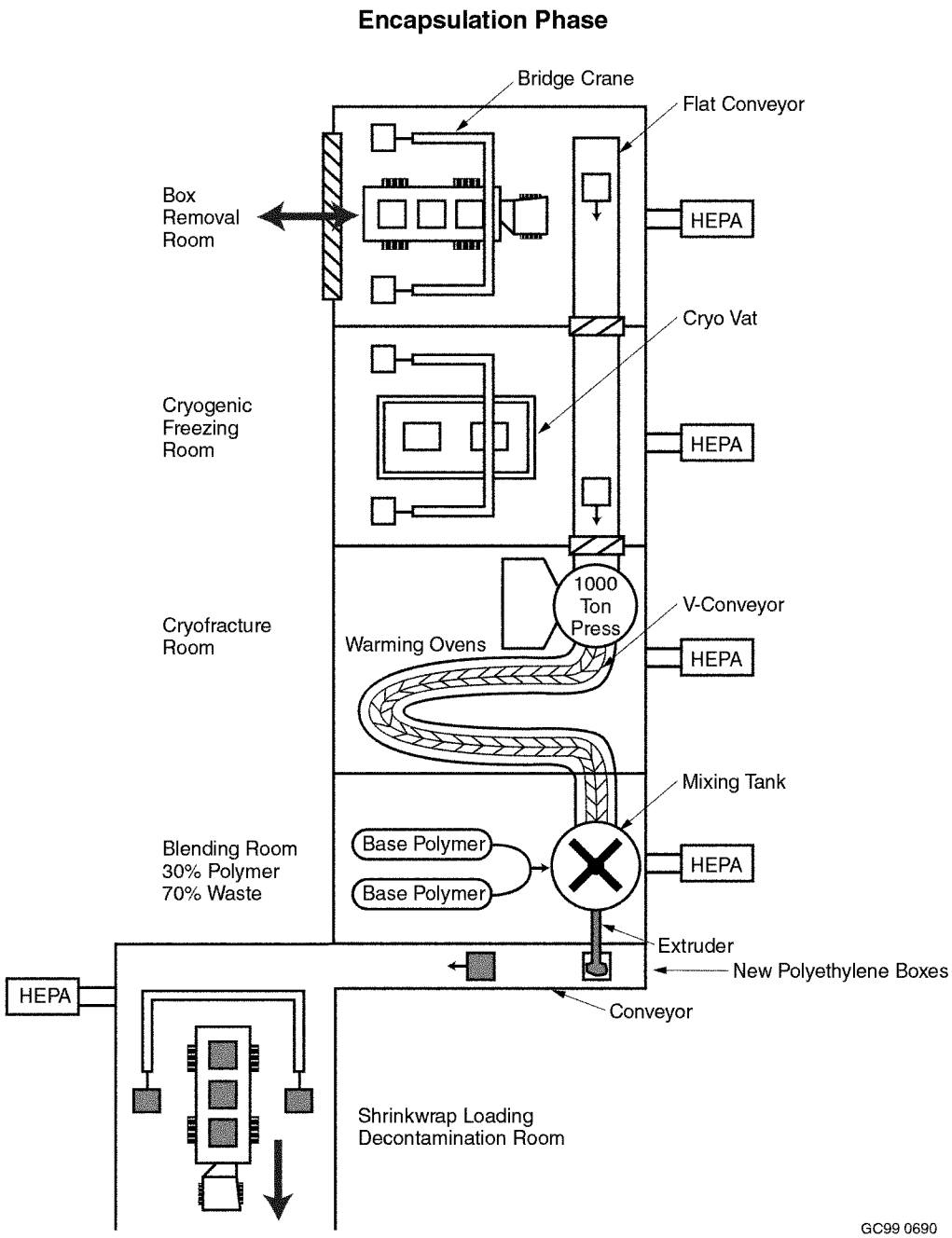

Figure 5. Encapsulation of the waste with low-melting temperature polyethylene.

The encapsulated waste is then stacked as shown in Figure 6 and covered with native soil and basaltic cobble for armoring. The top cover can be easily removed in the future if this technique does not meet performance specifications or other offsite options become expedient. In addition, any capping that is performed will be compatible with a full SDA final cap.

As an alternative, the encapsulated waste could be placed in single RCRA-approved storage buildings.

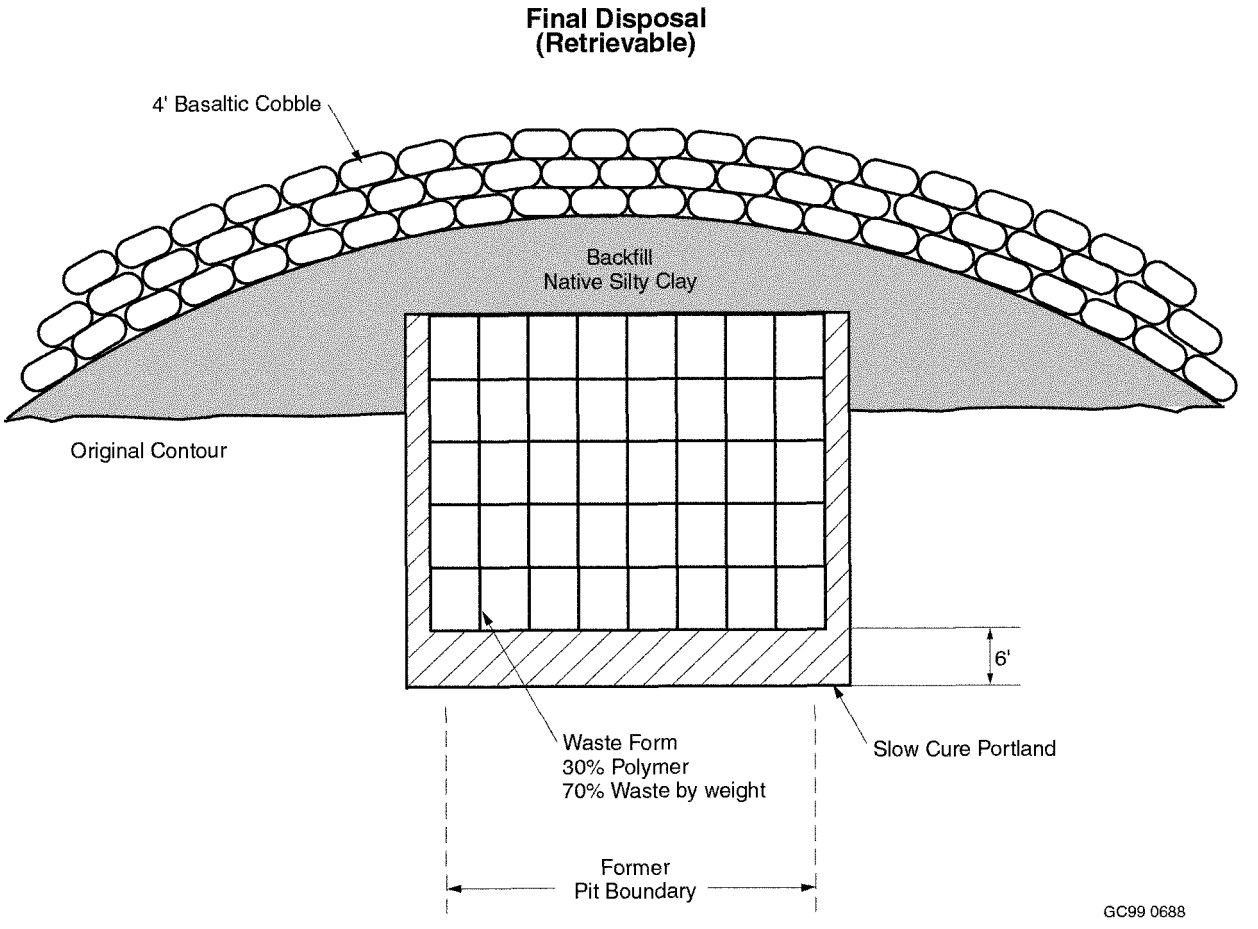

Figure 6. Retrieval final disposal option.

Cost Estimate

This section includes (1) a cost estimate for a treatability study performed under CERCLA for demonstration of retrieval to "retrievable disposal" for a one-acre sized transuranic pit, and (2) a cost estimate for complete remediation retrieval to "retrievable disposal" or interim storage for nine acres of buried transuranic waste.

Cost Estimate for a 1-Acre Region of Retrieval

The cost estimate is given for each of the major features: site preparation, grouting, retrieval, accumulation area, encapsulation, and either retrievable disposal or interim storage in RCRA-quality buildings for a the one-acre sized transuranic pit at the INEEL SDA. Also estimated are the total programmatic costs associated with managing the process. Not included in this cost estimate is the cost of producing an interim record of decision (ROD) for this national priorities list site. This permitting process could in all likelihood take longer than the 7 years estimated for the retrieval to "retrievable disposal" activities.

Site Preparation

Site preparation costs are summarized in Table 1.

Table 1. Site preparation cost summary.

	Process	Rate	$K
Labor and Equipment	Overburden leveling and stockpiling (approximately two ft of soil from one acre)	6 people × 160 hr × $60/hr	57
	Equipment rental	3 pieces × 30 days × $500/day	45
	Assay	1,000 samples at $100/sample	100
	Total equipment labor costs		$202
Capital Costs	1 Sprung building covering the pit		1,000
	2 Ancillary buildings Entrance and exit control		2,000
	Power 1 MW		250
	Fire suppression Remotely operated system		1,000
	Sample laboratory Rapid transuranic monitoring laboratory		500
	Subtotal capital		4,750
	Procurement labor adder		1,900
	Total capital costs		$6,650
Total ROM Estimate for Site Preparation			$6,852

Grouting

Grouting costs are summarized in Table 2.

Table 2. Grouting cost summary.

	Process	Rate	$K
Labor Costs	Training and consulting	4 people × 1,000 hr × $100/hr	400
	Grouting	4 people × 3,600 hr × $60/hr	864
	RADCON support	2 people × 3,600 hr × $60/hr	432
	Building maintenance support	1 person × 3,600 hr × $60	216
	Waste management	160 hr × $60/hr	9
	Waste disposal	200 ft3 × $500/ft3	100
	Laboratory samples	30 samples/day × 400 days × $100/sample	1,200
	Total Labor Costs		$3,221
Capital Costs	1 grouting unit (pumps, hoses, metering devices, drill rig, drill steel)		1,000
	1 X/Y support system		250
	Grout (14,000 holes × 100 gal/hole × $4.43/gal		6,202
	Subtotal capital		7,452
	Procurement labor adder		2,980
	Total capital costs		$10,432
Total ROM Estimate for Grouting			$13,653

Retrieval

Retrieval costs are summarized in Table 3.

Table 3. Retrieval costs summary.

	Process	Rate	$K
Labor Costs	10 equipment operators, 1 manager, 2 supervisors	13 people × 1,800 hours × $80/hr	1,872
	RADCON support	2 people × $80/hr × 1,800 hours	288
	RTML support	30 samples/day × 200 days × $100/sample	600
	ESH&Q support	1 × $80/hr × 1,800 hours	144
	Total Labor Costs		$2,904
Capital Costs	Heavy equipment with sealed cabs	$500K excavator $400K shear $100K forklift	1,000
	Shrink-wrap equipment	Custom built and installed	500
	Mats	43,000 ft^2 × $20	871
	Semi tractor trailer transporter		250
	Polyethylene transport boxes	6,806 × $50	340
	Gantry crane in shrink-wrap room		250
	Subtotal capital		3,211
	Procurement labor adder		1,477
	Total capital costs		4,688
Total ROM Estimate for Retrieval			$7,592

Accumulation Area

Accumulation Building costs are summarized in Table 4.

Table 4. Accumulation Building storage costs summary.

	Process	Rate	$K
Capital Costs	Basic storage building as used to support TSA		3,000
	Procurement adder		1,200
	Road Improvements	Paving $100/ft × 1,000 ft	100
Total ROM Estimate for Accumulation Building			$4,300

Encapsulation

Encapsulation costs are summarized in Table 5.

Table 5. Encapsulation costs summary.

	Process	Rate	$K
Labor and Material Costs	10 operators; 2 supervisors; 1 manager	13 people × 1,800 hours × $80/hr	1,872
	RADCON support	2 people × 1,800 hours × $80/hr	288
	ESH&Q support	1 × 1,800 hours × $80/hr	144
	Contamination control sampling	30 samples/day × 200 days × $100/sample	600
	Polyethylene	Assume waste is 43,560 ft^2 × 12 ft × 100 lb/ft^3 = 52,272,000 lb, and polyethylene at 0.30 mass loading = 15,681,600 at $1/ lb_m	15,681
	Liquid nitrogen	Per year	20
	Total Labor Costs		$18,605
Capital Costs	Building	4 chambers; loading dock;	3,000
	HEPA		2,000
	Fire suppression		1,000
	3 bridge cranes		750
	Cryofracture system		3,500
	Cryofracture heating system		500
	Conveyor system with controls		500
	Mixing tank and polyethylene heating/storage tanks		3,000
	Shrink-wrap system		500
	Subtotal capital costs		14,750
	Procurement adder		5,900
	Total Capital Costs		20,650
Total ROM Estimate for Encapsulation			$39,255

Retrievable Disposal

Disposal costs are summarized in Table 6.

Table 6. Retrievable Disposal cost estimate.

	Process	Rate	$K
Labor and Material Costs	Concrete labor	Estimated	1,018
	Tent removal and burial	10 operators × 160 hr × $80/hr	128
	Total Labor Costs		$1,146
Capital Costs	Backfill	50,000 ft^2 × 3 ft × $50/$yd^3$	277
	Backfill cobble	50000 ft^2 × 4 ft × $100/$yd^3$	740
	Concrete bottom	9,680 yd^3 × $100/$yd^3$	968
	Concrete sides	1,000 ft × $50/ft	50
	Subtotal capital costs		2,035
	Procurement adder		407
	Total Capital Costs		2,442
Total ROM Estimate for Retrievable Disposal			$3,588

Interim Storage Option

The cost for the interim storage option is simply 10 storage buildings times the estimated cost of $3 million per building plus $1 million for labor to move the encapsulated material to the interim storage buildings. There is no cost estimate for the final "unknown" disposition of this material.

Programmatic Costs

For a subcontractor to the DOE, project management costs are assured to be 20% of the total cost estimate. Again, this does not include the cost of obtaining a ROD for this action.

Summary Total ROM Estimate for 1 Acre

Table 7 shows the cost estimate for 1 acre.

Table 7. One-acre cost estimate.

Option 1 – Retrievable Disposal	$K
Site Preparation	6,852
Grouting	13,653
Retrieval	7,592
Accumulation	4,300
Encapsulation	39,255
Retrievable Disposal	3,588
Subtotal	75,240
Programmatic 1.2×	15,048
Total	$90,288
Option 2 – Interim Storage	**$K**
Site Preparation	6,852
Grouting	13,653
Retrieval	7,592
Accumulation	4,300
Encapsulation	39,255
Interim-Storage (10 buildings + labor)	31,000
Subtotal	102,652
Programmatic 0.2×	20,530
Total	$123,182

Cost of Application to 9 Acres within the SDA

The cost estimates for application to a nine-acre site are summarized in this section. Some assumptions are necessary when performing these tasks on nine acres, such as:

- Three grouting systems would be employed to reduce the grouting time from 18 years to 6 years
- The grouting systems and associated buildings and equipment would be reusable
- The retrieval effort would involve three retrieval systems and three encapsulation systems
- Grouting the first three pits would require 2 years; grouting, retrieval, encapsulation, and disposal would require an additional 5 years for the remaining 6 pits for a total of 7 years for the project.

None-Acre Cost Estimates

Cost estimates are summarized in Table 8.

Table 8. Nine-acre cost estimate.

	Option 1 – Retrievable Disposal	$K
1.	Site Preparation	
	Labor	2,718
	Capital (3 systems @ 6,650 each)	19,950
2.	Grouting	
	Labor	25,789
	Capital (3 systems and grout)	95,911
3.	Retrieval	
	Labor	26,136
	Capital (3 systems)	14,064
4.	Accumulation	
	Labor	500
	Capital (3 buildings total)	9,000
5.	Encapsulation	
	Labor/Materials	167,445
	Capital	61,950
6.	Retrievable Disposal	
	Disposal of last three pits*	10,764
	Disposal of first six pits	20,760
	Subtotal	454,987
	Project Management × 20%	90,997
	Total	$545,984

	Option 2 – Interim Storage	$K
1.	Site Preparation	
	Labor	2,718
	Capital (3 systems @ 6,650 each)	19,950
2.	Grouting	
	Labor	25,789
	Capital (3 systems + grout)	95,911
3.	Retrieval	
	Labor	26,136
	Capital (3 systems)	14,064
4.	Interim Storage**	
	Capital (building 90 x 3000)	270,000
	Labor	500
	Subtotal	455,068
	Project Management 20%	91,013
	Total	$546,081

*Disposal of weather shield on last three pits.

**Encapsulation was included in the one-acre treatability study, but not for the transuranic pits and trenches Interim Storage Option. The reason for this is that the Interim Storage is considered a temporary (20-year) solution, supporting an undefined storage (90 buildings) process for which polyethylene encapsulation may be incompatible.

Appendix J

Grouting Vendor Bid

Appendix J

Grouting Vendor Bid

The following vendor bid was prepared by Applied Geotechnical Engineering and Construction of Richland, Washington. This company was the grouting contractor on the in situ grouting treatability study at the INEEL as well as on past INEEL grouting projects. This bid was prepared as if the vendor was submitting a bid to do the work. There are two parts in the bid: one for the x-y positional system (discussed in Appendix I) and the other is using the thrust block concept that was reported in this report.

Part-1—Thrust Block or Cover Block Approach

A summary bid is provided as follows with the intent to provide guidance and foundation in comparison of technologies for waste management alternatives relative to solid waste interned at the Idaho National Engineering and Environmental Laboratory.

GENERAL REQUIREMENTS

1100 Summary

1107 Professional Consultant

Fees for architectural services, construction management, engineering, and surveying are not Included under this item.

Consultant fees of $500,000.00 for professional consultation for engineering/Geotechnical services/grout formulation/etc. over the 10-year duration of the project are included under this item.

1200 Price and Payment Procedures

1290 Payment Procedures

State and local taxes are assumed not applicable and are not included under this cost item.

1300 Administrative Requirements

1310 Project Management/Coordination

Permits will be the responsibility of others throughout the duration of this project.

Bonding including all performance, payment, and other surety bonds and related bonding for this project will be on the order of $7,130.000.00 which is approximately 1.5 percent of the total project cost. Bonding is estimated at the above rate in part due to the actual or perceived radiological and hazardous conditions at the project site in addition to the construction nature of the project.

The project duration is assumed as approximately 10 years.

Insurance for all aspects of the project for builders risk, equipment, public liability, pollution coverage, and related item are estimated at $ 1,900,181.00 from inception to completion of this remediation project. This estimate is nominally 0.4 percent of the project cost.

Main office expense, i.e., headquarters expense over the duration of the project are estimated at $18,526,760.00 or 3.9 percent of the total project cost over the duration of the project.

The overhead and profit for the total project is estimated nominally at 30 (fixed and general) and 10 percent, respectively.

Field personnel for administration include: (1) General manager/Project Manager, (2) Project Superintendent, (3) Project Engineer/Assistant Superintendent, (4) Administrative Assistant, (5) Planner/Scheduler, (6) Safety and Industrial Hygienist, (7) Health Physics Supervisor, (8) Quality Control Engineer, and (9) Secretary/Clerk, and (10) craft personnel. The above will be required for daily operation and a Superintendent/Assistant Superintendent and Health Physics Supervisor will be required off Shift. The total costs for the above over the 10-year project duration is estimated at $ 104,000,000.00.

1320 Construction Progress Documents

Construction project documents will be provided over the duration of the project by staff of the above item.

1400 Quality Requirements

1450 Quality Control

Quality control determination on materials over the 10 years of this project will be the responsibility of others. Quality control testing of equipment operations and durability however is estimated at $195,000.00 total cost over the duration of the project. This includes annual inspections and certifications of cranes and crane components, man lifts, truck tractors, truck trailers, rigging, and equivalent critical items.

1500 Temporary Facilities and Controls

1510 Temporary Utilities

Utilities utilized to support temporary offices, materials storage areas, shops, and related areas are the responsibility of others including electrical, mechanical, sanitation, communications, and equivalent site utilities. Costs for utilities for these structures are not included in this item.

1520 Construction Facilities

One general administrative office temporary modular building will be required to support project activities. One general meeting, conference room, and office modular building will be required to support operations and offsite personnel project activities. Three change rooms/lunchrooms will also be required to house site operations forces. Four storage containers will additionally be required for storage of site materials and site forces tools and craft materials. Office trailers and change rooms/lunchrooms are estimated as a one-time cost of $225,900.00. Storage containers are estimated to cost $20,000.00 as a one-time cost over the life of the project. Facilities and controls used to support project containment buildings and drilling/grouting operations are estimated at $245,900.00 over the 10-year duration of the project.

1530 Temporary Construction

All project facilities and all-weather conditions are considered as temporary conditions, hence this Item is considered not applicable.

1540 Construction Aids

Level d personal protective equipment for all site administration and labor over the duration of the project totals $200,000.00. This includes safety equipment such as hard hats, safety glasses, earplugs, gloves, substantial foot ware, coveralls, and cold weather apparel.

Level c and level b personal protective equipment used in radiological and mixed radiological and hazardous waste areas will include airline bottle-cart and escape-pack systems and breathing air, HEPA filtered masks and cleaning service, radiological coveralls with attached boots and hoods, shoe covers with cleaning service, and surgical gloves and work gloves. The total cost for this item over the 10 years of the project is estimated at $650,000.00.

1550 Vehicular Access and Parking

An area for staging of office trailers, change trailers, containers, shops, and parking facilities (approximately 2 acres) will be required during initial site activities. The cost for this activity is a one-time cost at $50,000.00.

1560 Barriers and Enclosures

Barriers and enclosures are not included under this item as the site will be located on U.S. Government property and radiological facilities will be located within a highly controlled fenced area.

Security personnel are not included in this item as it is assumed that security is the responsibility of others.

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Project signs will be installed at the onset of site activities relative to occupational safety and health requirements and throughout the duration of the project as required by industrial safety and radiological conditions. The cost estimate for this item is $10,000.00.

1590 Equipment

Jet grouting track drills will be required for injection of slurry into the subsurface waste materials. Data logging components will also be included to quantify drilling and grout slurry injection parameters. Each get grouting track drill is expected to last under operating conditions for 5 years. Two track drill units are intended to be used operationally with one unit as a backup unit. This backup unit is necessary due to project schedule constraints. Unit costs are approximated at $346,000.00 totaling $2,075,000.00 over the duration of the project. Spare parts for these units include slurry swivels, drilling rod, seals, and bit assemblies. The annual costs for these spare parts are $90,000.00 with a 10-year operational total of $900,000.00.

Jet grouting slurry pumps will be required for pumping slurry from a batch plant to the jet grouting track drill under pressure required for injection of slurry into waste and waste matrix materials. Each jet grouting slurry pump is expected to last for 5 years. The jet grouting slurry pump and power pack is an

integral unit which is containerized. The unit cost for each jet grouting slurry pump is $180,000.00 with a total cost of $1,800,000.00 for 6 units over the 10-year life of the project. Of the 6 units two will serve as backup units required due to project schedule constraints. Each year a major over haul of the pump system will be required. Hence, a spare parts 2,000-hour over haul kit is required for each unit. Unit costs for each overhaul kit is $50,000.00 with 24 kits required over the duration of the project that totals $1,200,000.00.

Jet grouting mix plants will be required for storing preblended dry grout materials, metering dry grout materials and water, and mixing and shearing these materials to produce grout slurry. Additionally, the plant pumps slurry to the above jet grouting slurry pump utilizing a low head centrifugal pump. This mixing plant utilizes an exterior dry materials hopper and auger to feed materials to the mixers/blenders, and a containerized unit with tanks, vortex mixers, and controls. The unit costs for these jet grouting mix plants are $75,000.00. It is assumed that two units will be used to serve each operational jet grouting slurry pump and one back unit will be kept in reserve with a total of 6 units. The reserve or backup units are required due to project schedule constraints. These units will be replaced each 5 years. The total costs for these units over the 10-year operational life of the project is $450,000.00. Spare parts for these mix plant units are estimated at $8,000 each with a requirement of 24 spare parts/rebuild kits over the duration of the project for total costs of $192,000.00.

Electrical generators are required to power the above jet grouting mix plant and to provide auxiliary power to the mix plant and the jet grouting slurry pump operating in series with the plant. These generators have requirements of 75 kilowatts and are capable of voltage rating up to 480 volts AC. Six generators will be required at a unit cost of $20,500.00 and a total cost over the duration of the project of $123,000.00. This estimate assumes replacement of generators twice during the life of the project.

Electrical generators are also required to power HVAC systems supporting grout injection operations. These systems include ventilation and HEPA filter operations within primary and secondary radiological containment areas. The power and voltage requirements for these units are 200 kilowatts and 480 volt AC, respectively. These generator units as above will be replaced twice over the duration of the project. Hence, 6 units will be required. The unit cost for each generator is $38,000.00 with a total project cost of $228,000.00.

A hydraulic crane with the capacity of nominally 40 tones will be required to support mobilization, operations, maintenance, transportation, and demobilization project activities. This crane is estimated to cost $250,000.00.

An end loader capable of multiple activities including initial plant grading, loading/offloading, materials handling, excavation, road/surface maintenance, and structure assembly/disassembly. The end loader will include fork and bucket assemblies. Unit cost for this equipment item is $320,000.00.

A large capacity water haul vehicle will be required to transport water from a site supplied water source to each bulk mixing plant. This unit will include pump capacity of offload bulk water. The one-time unit cost of this unit is $600,000.00.

All terrain man lifts are required for support and fabrication of operations. Two units are required for assembly of building structural components as well as disassembly. Additionally, these units will be required to service operations within building structures as a precursor to, during, and subsequent to grout slurry injection. The unit cost for these units is $120,000.00 with a total cost over the duration of the project of $240,000.00.

Off road heavy duty semi truck tractors will be required to transport dry bulk materials from bulk handling/railhead facilities. The unit cost for each tractor is estimated at $91,500.00 wherein four units are required. The total project cost for this item is estimated over the duration of the project at $366,000.00.

Large heavy duty dry materials transport trailers capable of transporting nominally 30 tonnes of dry product from rail head facilities to each grout dry mix facility are required. These trailers include mechanical/pneumatic systems for on loading and offloading of bulk powder. The unit cost of these trailers is $105,000.00 with three required over the duration of the project totaling $315,000.00.

A heavy-duty rock bulk haul trailer is required to support grout slurry cleanout operations. This trailer will haul bulk solidified grout materials from a cleanout area to an onsite stockpile area. The unit cost for this trailer delineated as a one-project time cost is $50,500.00.

A forklift of all terrain operations capacity is required for support of all project activities. This unit is also required to have high reach capacity in order to support building erection and disassembly. The one-time unit cost for this equipment is estimated at approximately $100,000.00.

Fuel required for all equipment/vehicles/power units/etc. will be supplied to the project from a local vendor and transported in a bulk fuel truck. The capacity of the fuel load of the truck is required at nominally 2,000 gal. The onetime unit cost for this bulk fuel truck is estimated at $100K.

A maintenance vehicle will be required to provide support to all jet grouting operations and ancillary project activities. This vehicle will include a large heavy duty off road truck with welder, oxy/acetylene cutting/welding, small capacity lift, tools, lubricants, air compressor, and related maintenance equipment. This one-time procurement unit cost is estimated at approximately $66.5K.

One off road utility truck with a nominal capacity of 2 tones is required for project support. The unit cost for this truck is $45K.

Utility trucks with off road capability are required to support this project from onset to completion. Four pickup trucks will be required over the duration of the project with a unit cost of $35K and a total project cost of $140K.

Portable light plants will be required to support interior lighting within grout injection confinement structures. Two units will be used per structure. These light plants will be replaced twice during the life of the project. The unit cost is $7K resulting in a project cost over 10 years of $42K.

Fuel required for operation of the above is estimated at $1,522,000 over the 10-year life of the project. This was estimated at 6 gal per hour for electrical generating equipment and 15 gal per hour for rolling stock, i.e., trucks, end loader, crane.

1700 Execution Requirements

1740 Cleaning

Site cleanup after construction and ongoing operations cleaning costs are included in general operations and not itemized here as a cost item.

1800 Facility Operations

1810 Commissioning

Training will be required for all site administrative and operations personnel. Required initial training for site, radiological, and hazardous worker, etc., training categories is estimated at $2,355.00 per person per year. Re-certification for staff after initial training is estimated at $840.00 per year. The total project cost for training is estimated at $753,540.00 over the complete 10-year duration of the project.

SITE CONSTRUCTION

IC Site Materials and Methods

2060 Aggregate

Aggregate will be required for site fill in and around offices, change rooms, containers, containment structures, and haul roads. Aggregate will also be used within containment structures during grout slurry injection preparation and operations. The cost for this material is $310,000.00.

2065 Concrete

Concrete will be required to support containment structures as structural footings. Concrete footings will also be used as a berm for containment of grout spoils. The cost for each footing item relative to each containment structure is nominally $870.00. Ten footing units will be required for an overall project cost of $87,000.00.

Concrete or grout is required over the area where grout injection has been completed. This material is used as a primary barrier covering the grout stabilized monolith. The depth of this barrier is 17 inches covering an area of 140 X 400 feet. Each grout barrier is estimated to cost $354,000.00. Hence, the total cost of 10 barriers is $3,540,000.00. This concrete grout material is assumed as a 2,500 pounds per cubic foot unconfined compressive strength, synthetic fiber reinforced, and self-leveling material. The unit cost for this material is $120.00 per cubic yard with 10 barriers required over the project duration. Hence, the total cost of primary barrier placement is $3,430,000,00.

Grout slurry will be produced on site by transport of dry grout materials from a railhead bulk storage plant to each grout mix plants, addition of water, and pumping through grout pumps and injection systems. On the order of 20,000 grout slurry holes are assumed per operational injection site. There are 10 operational injection sites. Slurry volume per hole is noted at 100 gal. The unit cost for grout slurry is $2.55 per gal. 24,000,000 gal of grout slurry is required for completion of monolith injection over the total project waste volume over the 10-year project volume. The total cost of grout slurry is estimated at $61,200,000.00. This assumes approximately 20 percent waste for spoils and cleanout.

5050 Metals

Two large containment structures will be used to confine grout slurry injection activities. Two each smaller support structures will be used to contain grout slurry mixing and shearing operations and grout high pressure pumping. One large containment structure will initially be fabricated along with smaller support structures. While these structures are under operations, another large containment structure and adjoining smaller support structures will be fabricated at another proximal location. Hence, one complete operational jet grouting system will be fabricated while the other is under operations, i.e., each system

will be fabricated initially and moved to another location for a total of 11 locations. This is required to meet a 10-year production schedule.

Each large confinement structure is conceptually designed at an operational height of 35 feet in order to accommodate jet grouting track drill mast height and drill rod stroke. The plan dimensions are assumed at 140 X 400 feet. Fabrication and dismantlement of each structure is assumed at 80 days each.

The cost for two of these large metal structure buildings, and spare/replacement parts assuming a one-time procurement is $2,620,000.00.

Each small support structure is conceptually designed at 20 X 24 X 50 feet with respect to height, width, and length, respectively. Four each of these structures (2 each) will be used to support jet grout mixing/batching and high pressure pumping for each large containment structure. As per the above large containment buildings each of the small jet grouting support buildings will be moved for a total of 11 locations. One of the above small structures will be utilized as a project maintenance and shop facility. The project maintenance and shop facility will not be moved from its original location.

The cost for 5 support structures is estimated at $225,000.00 assuming a one-time procurement over the life of the project.

Large cover blocks are required to provide containment of contaminants during jet grouting operations. These structures consist of an upper surface of steel plates with internal steel bracing. Further, these structures are bounded on each side by structural steel with ports used to permit attachment of HEPA filtration systems. The top also has removable ports for insertion of jet grouting drill steel. Ports are especially designed with primary and secondary plastic cylindrical boots used to isolate the drill steel from the personnel work area. The cover block assemblies are of sufficient strength to permit operation of heavy equipment on their surface. The cover blocks are leveled above each drilling location and brought to grade with aggregate.

Cover blocks sufficient to cover a plan area of 11 acres will be required. The total cost of these assemblies is estimated at $283,800,000.00.

15050 Mechanical

Two large structures will be used to confine jet grouting injection activities. To support work in these structures for year-round operations, heating, air conditioning, and ventilation (HVAC) will be required. Heating will be provided with high capacity propane or equivalent gas. Propane or equivalent gas will be supplied onsite by a 15,000-gal storage tank or two 7,500-gal tanks. Propane storage will require a fenced, lined, and barricaded area. Air conditioning will be supplied with evaporative cooling. Air circulation within each large containment building will be filtered continually through high capacity high efficiency particulate air filters. HEPA filters will be tested by others.

Two HVAC complete systems are estimated at a one-time cost of $2,500.000.00. This cost assumes utilization of two HVAC complete systems for 5 years, replacement and operation of the systems for the remaining 5 years. Also included are all spare parts and related materials. The cost of propane over the 10-year life of the project is estimated at $1,000,000.00

16050 Electrical

Two camera systems are required for evaluation of operations of jet grouting drilling, grout slurry placement, spoils returns, and general equipment operations. Two camera/recording/viewing systems will

be positioned to cover each jet grouting track drill injection module. This configuration assumes 2 of the above systems per containment structure, or four systems overall.

The one-time cost of these systems including recording media for all grout slurry injection holes is estimated at $280,000.00.

R130 Special Construction

It is assumed that a railhead located at the site will be used for delivery and offloading of dry bulk materials from hopper rail cars. Due to the volume of dry bulk materials required per unit time over the duration of the project, 2 large dry bulk storage silos located at the railhead, and 3 smaller silos located proximal to each jet grouting mixing/batching operation are required for efficient supply of grout former materials to each injection operation. Two large silos and mechanical/pneumatic of offloading equipment with a storage capacity of nominally 550 tones each will be constructed at the railhead. Dry bulk materials will be offloaded from these silos as needed and transported to one of 3 each smaller silos servicing each jet grouting operation.

The total cost for these 5 items as a one-time project cost is estimated at $691,000.00.

Three water portable heated water tanks will be required to support each jet grouting mixing/batching operation, i.e., two operational and one backup tank as above.

The total cost for these tanks over the live of the project is anticipated at approximately $36,000.00.

Specially designed drill shrouds are required to isolate contaminants from drilling operations entering into personnel spaces within the large containment structure covering each drilling location. Numerous isolation shrouds consisting of coaxial flexible bellows oriented axially over the drill rods and attached to the jet grouting track drill mast assembly will be needed. The operational life of each shroud is estimated at 300 holes. Hence, assuming 30 holes can be drilled with each shroud assembly per each shift then 80 shrouds will be required. With a unit cost of $15,000.00 the total estimated cost of shrouds over the life of the project is nominally $1,200,000.00.

Crews

Summary

Administrative staff will be required at conception and throughout the duration of the project. This administrative function is assumed totally dedicated to the project and works directly for the project including interfacing with site personnel and programmatic staff from the site. A building construction crew working under the direction of the administrative staff will be required to build containment building structures, dismantle containment structures, and reassemble these structures over the duration of the project. The building construction crew will also erect bulk storage and materials handling facilities and equipment as well as dismantlement and decommissioning of the site on project completion. Operations crews will complete operations of equipment and support equipment directed to placement of subsurface grout materials.

Administrative staff will be required during one shift with one superintendent working off shift. The building construction crew will only work one shift. Two operations crews will be required, i.e., one crew per two shifts. Shifts are assumed as 10 hours in duration over a 5-day workweek.

Administration

A project general manager will be required with the responsibility of overall project administration, operations, and control. A site superintendent for each of two shifts will be required for supervision of all site operations. One project engineer will be required to support site engineering and to serve as an assistant superintendent. Two administrative assistants will be required to perform clerical and related functions in support of all administrative staff. One bookkeeper/timekeeper will be required to perform accounting and payroll activities. One planner/scheduler will be needed to assist in development and projection of task activities and to determine staffing requirements. An industrial hygienist will be required to develop and control safety and health programs, one per shift. Two health physics supervisors will be required to control and manage radiological programs, one per shift. A quality control administrator will also be required to develop and manage quality programs and to perform inspections. The total administrative staff consists of 13 persons.

Building Construction

Building construction activities will require a dedicated crew consisting of one working general foreman, one crane and heavy equipment operator, 6 ironworkers, and one laborer. The total manpower requirement for this activity is 9. If required, additional staff may be reassigned temporarily from and operations crew.

Operations

Grout placement operations will require a substantial crew. There will be two crews per working day. Each crew consists of one working general foreman to oversee all applicable dry bulk storage and transfer, water transfer, slurry mixing/pumping/and injection, waste haulage, etc., as well as operations of all system components. This functions will in turn be administered be a shift superintendent. Two mechanics will be required to perform preventative as well as general maintenance on all equipment and materials handling components. One electrician and 1 instrument technician will be required to perform component installation, operations, and disassembly related to electrical systems. These staff will also be responsible for electrical generating systems. Four track drill operators, simultaneously operating two injection systems per shift will be needed. Jet grouting pump operations, 2 each supporting each track drill injection system, feeding grout slurry to grout injection track drill components will require 2 operators. In turn, 2 bulk mixing plants supplying mixed and sheared slurry to each jet grouting pump will require 1 operator each. Two relief operators are required to cover each jet grouting drill injection, jet grouting pump, and jet grouting batching/mixing operations as a contingency. One heavy equipment operator will be required to support operations utilizing front-end loader, all terrain fork lift, hydraulic crane, etc. Six teamsters are required to support grout injection and related project operations. These activities include fuel transport and fueling, water transport, bulk dry materials loading/off loading and transport, parts and materials pick up and delivery, and solidified waste grout transport and landfill operations offloading. Three laborers will be required for general site and operations support including control of radiological personal protective equipment. Two radiological technicians will be required to support each grout injection track drill activity. The total operations staff for two shifts consists of 54 craftsmen. Cross craft activities are also assumed where specific training requirements are not limiting. Where required lead individuals per craft may be assigned for supervisory actions under each shift general foreman and shift superintendent.

Assumptions

Numerous assumptions have been delineated for this project limiting the estimate of project cost and cost projections. Assumptions are listed as follows:

- Waste stabilization will be performed under a reusable structure.
- Batching/mixing of grout slurry will be completed on site (at the location of injection).
- Waste stabilization will be completed with ah injection density o 2,000 injection holes per acre.
- There are 10 locations of 1 acre each with generalized plan dimensions of 140 X 400 feet.
- Nominally each grout injection hole will be 10 feet in depth through the waste depth interval and 100 gal of grout will be used per injection.
- The project duration is on the order of 10 years.
- All equipment and materials delivered to the site are new and not previously used in production.
- Weekly work duration is 10 hours per day, 5 days per week. Operations will work two shifts of 10 hours each per day for 5 days each week. Administration will work one shift of 10 hours 5 days per week.
- Weather protection will be required for equipment and personnel within confinement and support structures.
- No release of radiological or hazardous contamination will occur as a function of jet grouting operations or support activities.
- Only minimal travel and per diem will be allowed and for only administrative staff.
- Grout placement includes a 17-inch thick grout or equivalent material cap over each drilling location and no further capping is required.
- Costs are provided in government Fiscal Year 2002 and are escalated at 3% per year over the project duration of 10 years where applicable.
- All project work is covered under Price – Anderson and related nuclear and hazardous materials liability and general requirements acts.
- Intellectual property, licensing, and related fees are the responsibility of others and are not included herein.
- All state and government taxes relative to project operations excluding personnel taxes etc., are the responsibility of others if applicable.
- Site security and patrol and site utilities, i.e., overhead electrical, potable and nonpotable process water, telephone, sanitary sewer or equivalent, and noncontaminated solid waste collection and disposal are provided by others.

- HEPA filter testing, and delivery to the project site are the responsibility of others.
- Site engineering surveys and waste location surveys if required are the responsibility of others.
- Costs associated with U.S. Department of Energy and/or Maintenance and Operations or Construction management and oversight are not included in this estimate.
- Administration, engineering, health physics, quality, training, safety, operations and associated records will be transmitted to applicable contractor offices and will be the responsibility of others.
- General site operations facilities and services will be available for project staff at nominal cost including but not limited to, general site training, specific craft training, radiological and hazardous materials training, fire/patrol support and control, and physical examinations.
- At the completion of project operations, jet grouting injection and support structures will be dismantled and staged, administrative and maintenance structures will be cleaned, isolated, winterized, and equipment will be winterized and staged onsite. These facilities/equipment/materials/etc. will be the property of the government.
- All equipment and materials are free on board INEEL.
- Dosimetry/dosimetry records, medical, testing and certification/medical records and associated programs are the responsibility of others.
- Safety analysis reports/reviews will be completed by others prior to contract award.
- Administrative, industrial safety and health, radiological control, quality, operations, etc., programs and plans be sued by the maintenance and operations site contractor will be adopted and approved prior to contract award.
- Engineering design of building structures and support structures/cover block/shroud will be the responsibility of others.

Part 2—X-Y Positional System Gantry Crane Approach

A summary cost estimate is provided as follows with the intent to provide guidance and foundation in comparison of technologies for waste management alternatives relative to solid waste interned at the Idaho National Engineering and Environmental Laboratory.

GENERAL REQUIREMENTS

1100 Summary

1107 Professional Consultant

Fees for architectural services, construction management, engineering, and surveying are not Included under this item.

Consultant fees of $500,000.00 for professional consultation for engineering/Geotechnical services/grout formulation/etc. over the 10-year duration of the project are included under this item.

1200 Price and Payment Procedures

1290 Payment Procedures

State and local taxes are assumed not applicable and are not included under this cost item.

1300 Administrative Requirements

1310 Project Management/Coordination

Permits will be the responsibility of others throughout the duration of this project.

Bonding including all performance, payment, and other surety bonds and related bonding for this project will be on the order of $3,000,000.00 which is approximately 1.5 percent of the total project cost. Bonding is estimated at the above rate in part due to the actual or perceived radiological and hazardous conditions at the project site in addition to the construction nature of the project.

The project duration is assumed as approximately 10 years.

Insurance for all aspects of the project for builders risk, equipment, public liability, pollution coverage, and related item are estimated at $791,841.00 from inception to completion of this remediation project. This estimate is nominally 0.4 percent of the project cost.

Main office expense, i.e., headquarters expense over the duration of the project are estimated at $7,720,445.00 or 3.9 percent of the total project cost over the duration of the project.

The overhead and profit for the total project is estimated nominally at 30 (fixed and general) and 10 percent, respectively.

Field personnel for administration include: (1) General manager/Project Manager, (2) Project Superintendent, (3) Project Engineer/Assistant Superintendent, (4) Administrative Assistant, (5) Planner/Scheduler, (6) Safety and Industrial Hygienist, (7) Health Physics Supervisor, (8) Quality Control Engineer, and (9) Secretary/Clerk, and (10) craft personnel. The above will be required for daily operation and a Superintendent/Assistant Superintendent and Health Physics Supervisor will be required off Shift. The total costs for the above over the 10-year project duration is estimated at $104,000,000.00.

1320 Construction Progress Documents

Construction project documents will be provided over the duration of the project by staff of the above item.

1400 Quality Requirements

1450 Quality Control

Quality control determination on materials over the 10 years of this project will be the responsibility of others. Quality control testing of equipment operations and durability however is estimated at $195,000.00 total cost over the duration of the project. This includes annual inspections and certifications of cranes and crane components, man lifts, truck tractors, truck trailers, rigging, and equivalent critical items.

1500 Temporary Facilities and Controls

1510 Temporary Utilities

Utilities utilized to support temporary offices, materials storage areas, shops, and related areas are the responsibility of others including electrical, mechanical, sanitation, communications, and equivalent site utilities. Costs for utilities for these structures are not included in this item.

1520 Construction Facilities

One general administrative office temporary modular building will be required to support project activities. One general meeting, conference room, and office modular building will be required to support operations and offsite personnel project activities. Three change rooms/lunchrooms will also be required to house site operations forces. Four storage containers will additionally be required for storage of site materials and site forces tools and craft materials. Office trailers and change rooms/lunchrooms are estimated as a one-time cost of $225,900.00. Storage containers are estimated to cost $20,000.00 as a one-time cost over the life of the project. Facilities and controls used to support project containment buildings and drilling/grouting operations are estimated at $245,900.00 over the 10-year duration of the project.

1530 Temporary Construction

All project facilities and all-weather conditions are considered as temporary conditions, hence this Item is considered not applicable.

1540 Construction Aids

Level d personal protective equipment for all site administration and labor over the duration of the project totals $200,000.00. This includes safety equipment such as hard hats, safety glasses, earplugs, gloves, substantial foot ware, coveralls, and cold weather apparel.

Level c and level b personal protective equipment used in radiological and mixed radiological and hazardous waste areas will include airline bottle-cart and escape-pack systems and breathing air, HEPA filtered masks and cleaning service, radiological coveralls with attached boots and hoods, shoe covers with cleaning service, and surgical gloves and work gloves. The total cost for this item over the 10 years of the project is estimated at $650,000.00.

1550 Vehicular Access and Parking

An area for staging of office trailers, change trailers, containers, shops, and parking facilities (approximately 2 acres) will be required during initial site activities. The cost for this activity is a one-time cost at $50,000.00.

Barriers and Enclosures

Barriers and enclosures are not included under this item as the site will be located on U.S. Government property and radiological facilities will be located within a highly controlled fenced area.

Security personnel are not included in this item as it is assumed that security is the responsibility of others.

1580 Project Signs

Project signs will be installed at the onset of site activities relative to occupational safety and health requirements and throughout the duration of the project as required by industrial safety and radiological conditions. The cost estimate for this item is $10,000.00.

1590 Equipment

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Jet grouting mix plants will be required for storing preblended dry grout materials, metering dry grout materials and water, and mixing and shearing these materials to produce grout slurry. Additionally, the plant pumps slurry to the above jet grouting slurry pump utilizing a low head centrifugal pump. This mixing plant utilizes an exterior dry materials hopper and auger to feed materials to the mixers/blenders, and a containerized unit with tanks, vortex mixers, and controls. The unit costs for these jet grouting mix plants are $75,000.00. It is assumed that two units will be used to serve each operational jet grouting slurry pump and one back unit will be kept in reserve with a total of 6 units. The reserve or backup units are required due to project schedule constraints. These units will be replaced each 5 years. The total costs for these units over the 10-year operational life of the project is $450,000.00. Spare parts for these mix plant units are estimated at $8,000 each with a requirement of 24 spare parts/rebuild kits over the duration of the project for total costs of $192,000.00.

Electrical generators are required to power the above jet grouting mix plant and to provide auxiliary power to the mix plant and the jet grouting slurry pump operating in series with the plant. These generators have requirements of 75 kilowatts and are capable of voltage rating up to 480 volts AC. Six generators will be required at a unit cost of $20,500.00 and a total cost over the duration of the project of $123,000.00. This estimate assumes replacement of generators twice during the life of the project.

Electrical generators are also required to power HVAC systems supporting grout injection operations. These systems include ventilation and HEPA filter operations within primary and secondary radiological containment areas. The power and voltage requirements for these units are 200 kilowatts and 480 volt AC, respectively. These generator units as above will be replaced twice over the duration of the project. Hence, 6 units will be required. The unit cost for each generator is $38,000.00 with a total project cost of $228,000.00.

A hydraulic crane with the capacity of nominally 40 tones will be required to support mobilization, operations, maintenance, transportation, and demobilization project activities. This crane is estimated to cost $250,000.00.

An end loader capable of multiple activities including initial plant grading, loading/offloading, materials handling, excavation, road/surface maintenance, and structure assembly/disassembly. The end loader will include fork and bucket assemblies. Unit cost for this equipment item is $320,000.00.

A large capacity water haul vehicle will be required to transport water from a site supplied water source to each bulk mixing plant. This unit will include pump capacity of offload bulk water. The one-time unit cost of this unit is $600,000.00.

All terrain man lifts are required for support and fabrication of operations. Two units are required for assembly of building structural components as well as disassembly. Additionally, these units will be required to service operations within building structures as a precursor to, during, and subsequent to grout slurry injection. The unit cost for these units is $120,000.00 with a total cost over the duration of the project of $240,000.00.

Off road heavy duty semi truck tractors will be required to transport dry bulk materials from bulk handling/railhead facilities. The unit cost for each tractor is estimated at $91,500.00 wherein four units are required. The total project cost for this item is estimated over the duration of the project at $366,000.00.

Large heavy duty dry materials transport trailers capable of transporting nominally 30 tonnes of dry product from rail head facilities to each grout dry mix facility are required. These trailers include mechanical/pneumatic systems for on loading and offloading of bulk powder. The unit cost of these trailers is $105,000.00 with three required over the duration of the project totaling $315,000.00.

A heavy-duty rock bulk haul trailer is required to support grout slurry cleanout operations. This trailer will haul bulk solidified grout materials from a cleanout area to an onsite stockpile area. The unit cost for this trailer delineated as a one-project time cost is $50,500.00.

A forklift of all terrain operations capacity is required for support of all project activities. This unit is also required to have high reach capacity in order to support building erection and disassembly. The one-time unit cost for this equipment is estimated at approximately $100,000.00.

Fuel required for all equipment/vehicles/power units/etc. will be supplied to the project from a local vendor and transported in a bulk fuel truck. The capacity of the fuel load of the truck is required at nominally 2000 gal. The onetime unit cost for this bulk fuel truck is estimated at $100,000.00.

A maintenance vehicle will be required to provide support to all jet grouting operations and ancillary project activities. This vehicle will include a large heavy duty off road truck with welder, oxy/acetylene cutting/welding, small capacity lift, tools, lubricants, air compressor, and related maintenance equipment. This one-time procurement unit cost is estimated at approximately $66,500.00.

One off road utility truck with a nominal capacity of 2 tones is required for project support. The unit cost for this truck is $45,000.00

Utility trucks with off road capability are required to support this project from onset to completion. Four pickup trucks will be required over the duration of the project with a unit cost of $35,000.00 and a total project cost of $140,000.00.

Portable light plants will be required to support interior lighting within grout injection confinement structures. Two units will be used per structure. These light plants will be replaced twice during the life of the project. The unit cost is $7,000.00 resulting in a project cost over 10 years of $42,000.00.

Fuel required for operation of the above is estimated at $1,522,000.00 over the 10-year life of the project. This was estimated at 6 gal per hour for electrical generating equipment and 15 gal per hour for rolling stock, i.e., trucks, end loader, crane.

1700 Execution Requirements

1740 Cleaning

Site cleanup after construction and ongoing operations cleaning costs are included in general operations and not itemized here as a cost item.

1800 Facility Operations

1810 Commissioning

Training will be required for all site administrative and operations personnel. Required initial training for site, radiological, and hazardous worker, etc., training categories is estimated at $2,355.00 per person per year. Re-certification for staff after initial training is estimated at $840.00 per year. The total project cost for training is estimated at $753,540.00 over the complete 10-year duration of the project.

SITE CONSTRUCTION

IC Site Materials and Methods

2060 Aggregate

Aggregate will be required for site fill in and around offices, change rooms, containers, containment structures, and haul roads. Aggregate will also be used within containment structures during grout slurry injection preparation and operations. The cost for this material is $310,000.00.

2065 Concrete

Concrete will be required to support containment structures as structural footings. Concrete footings will also be used as a berm for containment of grout spoils. The cost for each footing item relative to each containment structure is nominally $870.00. Ten footing units will be required for an overall project cost of $87,000.00.

Concrete or grout is required over the area where grout injection has been completed. This material is used as a primary barrier covering the grout stabilized monolith. The depth of this barrier is 17 inches covering an area of 140 X 400 feet. Each grout barrier is estimated to cost $354,000.00. Hence, the total cost of 10 barriers is $3,540,000.00. This concrete grout material is assumed as a 2,500 pounds per cubic foot unconfined compressive strength, synthetic fiber reinforced, and self-leveling material. The unit cost for this material is $120.00 per cubic yard with 10 barriers required over the project duration. Hence, the total cost of primary barrier placement is $3,430,000,00.

Grout slurry will be produced on site by transport of dry grout materials from a railhead bulk storage plant to each grout mix plants, addition of water, and pumping through grout pumps and injection systems. On the order of 20,000 grout slurry holes are assumed per operational injection site. There are 10 operational injection sites. Slurry volume per hole is noted at 100 gal. The unit cost for grout slurry is $2.55 per gal. 24,000,000 gal of grout slurry is required for completion of monolith injection over the total project waste volume over the 10-year project volume. The total cost of grout slurry is estimated at $61,200,000.00. This assumes approximately 20 percent waste for spoils and cleanout.

5050 Metals

Two large containment structures will be used to confine grout slurry injection activities. Two each smaller support structures will be used to contain grout slurry mixing and shearing operations and grout high pressure pumping. One large containment structure will initially be fabricated along with smaller support structures. While these structures are under operations, another large containment structure and adjoining smaller support structures will be fabricated at another proximal location. Hence, one complete operational jet grouting system will be fabricated while the other is under operations, i.e., each system will be fabricated initially and moved to another location for a total of 11 locations. This is required to meet a 10-year production schedule.

Within each large containment structure is affixed an internal radiological containment liner and change out/decontamination liner. This liner is attached to the large metal containment structure overhead and is of approximate dimensions of 35 X 120 X 400 feet with respect to height, width, and length. This liner is sacrificed at the culmination of jet grouting operations for each location.

The cost for two of these large metal structure buildings, and spare/replacement parts assuming a one-time procurement is $2,620,000.00.

The unit cost for each containment liner is estimated at $160,000.00 with a total project cost of $1,760,000.00.

Each large confinement structure is conceptually designed at an operational height of 35 feet in order to accommodate jet grouting track drill mast height and drill rod stroke. The plan dimensions are assumed at 140 X 400 feet. Fabrication and dismantlement of each structure is assumed at 80 days each.

Each small support structure is conceptually designed at 20 X 24 X 50 feet with respect to height, width, and length, respectively. Four each of these structures (2 each) will be used to support jet grout mixing/batching and high pressure pumping for each large containment structure. As per the above large containment buildings each of the small jet grouting support buildings will be moved for a total of 11 locations. One of the above small structures will be utilized as a project maintenance and shop facility. The project maintenance and shop facility will not be moved from its original location.

The cost for 5 support structures is estimated at $225,000.00 assuming a one-time procurement over the life of the project.

15050 Mechanical

Two large structures will be used to confine jet grouting injection activities. To support work in these structures for year-round operations, heating, air conditioning, and ventilation (HVAC) will be required. Heating will be provided with high capacity propane or equivalent gas. Propane or equivalent gas will be supplied onsite by a 15,000-gal storage tank or two 7,500-gal tanks. Propane storage will require a fenced, lined, and barricaded area. Air conditioning will be supplied with evaporative cooling.

Air circulation within each large containment building will be filtered continually through high capacity high efficiency particulate air filters. HEPA filters will be tested by others.

Two HVAC complete systems are estimated at a one-time cost of $2,500.000.00. This cost assumes utilization of two HVAC complete systems for 5 years, replacement and operation of the systems for the remaining 5 years. Also included are all spare parts and related materials. The cost of propane over the 10-year life of the project is estimated at $1,000,000.00

16050 Electrical

Two camera systems are required for evaluation of operations of jet grouting drilling, grout slurry placement, spoils returns, and general equipment operations. Two camera/recording/viewing systems will be positioned to cover each jet grouting track drill injection module. This configuration assumes 2 of the above systems per containment structure, or four systems overall.

The one-time cost of these systems including recording media for all grout slurry injection holes is estimated at $280,000.00.

R130 Special Construction

Three gantry modules capable of movement longitudinally and laterally in a planar configuration over the footprint of the waste location within a large containment structure are required. Two used operationally, and 1 as a backup. This is required in order to meet production schedules. These gantries additionally are required to penetrate through the soil overburden and into the waste zone containing soil matrix materials and waste materials. Penetration will be achieved by insertion of drill steel and appropriate drilling bits and jet grouting appurtenances. Hence, the gantry is functionally a mechanical system capable of three-dimensional operation, i.e., in the x, y, and z axes. The gantry and attached track drill mast and drilling assembly will be powered by a hydraulic power pack operated outside of the primary large metal confinement structure. Operation of the gantry will be remotely by radio control.

The cost of each gantry and all associated railings, hydraulics, equipment, power supplies, servomotors, radio controllers etc, is estimated at $2,100,000.00 with a total one-time project procurement cost of $6,300,000.00.

It is assumed that a railhead located at the site will be used for delivery and offloading of dry bulk materials from hopper rail cars. Due to the volume of dry bulk materials required per unit time over the duration of the project, 2 large dry bulk storage silos located at the railhead, and 3 smaller silos located proximal to each jet grouting mixing/batching operation are required for efficient supply of grout former materials to each injection operation. Two large silos and mechanical/pneumatic of offloading equipment with a storage capacity of nominally 550 tones each will be constructed at the railhead. Dry bulk materials will be offloaded from these silos as needed and transported to one of 3 each smaller silos servicing each jet grouting operation.

The total cost for these 5 items as a one-time project cost is estimated at $691,000.00.

Three water portable heated water tanks will be required to support each jet grouting mixing/batching operation, i.e., two operational and one backup tank as above.

The total cost for these tanks over the live of the project is anticipated at approximately $36,000.00.

Crews

Summary

Administrative staff will be required at conception and throughout the duration of the project. This administrative function is assumed totally dedicated to the project and works directly for the project including interfacing with site personnel and programmatic staff from the site. A building construction crew working under the direction of the administrative staff will be required to build containment building structures, dismantle containment structures, and reassemble these structures over the duration of the project. The building construction crew will also erect bulk storage and materials handling facilities and equipment as well as dismantlement and decommissioning of the site on project completion. Operations crews will complete operations of equipment and support equipment directed to placement of subsurface grout materials.

Administrative staff will be required during one shift with one superintendent working off shift. The building construction crew will only work one shift. Two operations crews will be required, i.e., one crew per two shifts. Shifts are assumed as 10 hours in duration over a 5-day workweek.

Administration

A project general manager will be required with the responsibility of overall project administration, operations, and control. A site superintendent for each of two shifts will be required for supervision of all site operations. One project engineer will be required to support site engineering and to serve as an assistant superintendent. Two administrative assistants will be required to perform clerical and related functions in support of all administrative staff. One bookkeeper/timekeeper will be required to perform accounting and payroll activities. One planner/scheduler will be needed to assist in development and projection of task activities and to determine staffing requirements. An industrial hygienist will be required to develop and control safety and health programs, one per shift. Two health physics supervisors will be required to control and manage radiological programs, one per shift. A quality control administrator will also be required to develop and manage quality programs and to perform inspections. The total administrative staff consists of 13 persons.

Building Construction

Building construction activities will require a dedicated crew consisting of one working general foreman, one crane and heavy equipment operator, 6 ironworkers, and one laborer. The total manpower requirement for this activity is 9. If required, additional staff may be reassigned temporarily from and operations crew.

Operations

Grout placement operations will require a substantial crew. There will be two crews per working day. Each crew consists of one working general foreman to oversee all applicable dry bulk storage and transfer, water transfer, slurry mixing/pumping/and injection, waste haulage, etc., as well as operations of all system components. This functions will in turn be administered be a shift superintendent. Two mechanics will be required to perform preventative as well as general maintenance on all equipment and materials handling components. One electrician and 1 instrument technician will be required to perform component installation, operations, and disassembly related to electrical systems. These staff will also be responsible for electrical generating systems. Four track drill operators, simultaneously operating two injection systems per shift will be needed. Jet grouting pump operations, 2 each supporting each track drill injection system, feeding grout slurry to grout injection track drill components will require 2

operators. In turn, 2 bulk mixing plants supplying mixed and sheared slurry to each jet grouting pump will require 1 operator each. Two relief operators are required to cover each jet grouting drill injection, jet grouting pump, and jet grouting batching/mixing operations as a contingency. One heavy equipment operator will be required to support operations utilizing front-end loader, all terrain fork lift, hydraulic crane, etc.. Six teamsters are required to support grout injection and related project operations. These activities include fuel transport and fueling, water transport, bulk dry materials loading/off loading and transport, parts and materials pick up and delivery, and solidified waste grout transport and landfill operations offloading. Three laborers will be required for general site and operations support including control of radiological personal protective equipment. Two radiological technicians will be required to support each grout injection track drill activity. The total operations staff for two shifts consists of 54 craftsmen. Cross craft activities are also assumed where specific training requirements are not limiting. Where required lead individuals per craft may be assigned for supervisory actions under each shift general foreman and shift superintendent.

ASSUMPTIONS

Numerous assumptions have been delineated for this project limiting the estimate of project cost and cost projections. Assumptions are listed as follows:

- Waste stabilization will be performed under a reusable structure.
- Batching/mixing of grout slurry will be completed on site (at the location of injection).
- Waste stabilization will be completed with ah injection density o 20,000 injection holes per acre.
- There are 11 locations of 1 acre each with generalized plan dimensions of 140 x 400 feet.
- Nominally each grout injection hole will be 10 feet in depth through the waste depth interval and 100 gal of grout will be used per injection.
- The project duration is on the order of 10 years.
- All equipment and materials delivered to the site are new and not previously used in production.
- Weekly work duration is 10 hours per day, 5 days per week. Operations will work two shifts of 10 hours each per day for 5 days each week. Administration will work one shift of 10 hours 5 days per week.
- Weather protection will be required for equipment and personnel within confinement and support structures.
- No release of radiological or hazardous contamination will occur as a function of jet grouting operations or support activities.
- Only minimal travel and per diem will be allowed and for only administrative staff.
- Grout placement includes a 17-inch thick grout or equivalent material cap over each drilling location and no further capping is required.

- Costs are provided in government Fiscal Year 2002 and are escalated at 3% per year over the project duration of 10 years where applicable.

- All project work is covered under Price – Anderson and related nuclear and hazardous materials liability and general requirements acts.

- Intellectual property, licensing, and related fees are the responsibility of others and are not included herein.

- All state and government taxes relative to project operations excluding personnel taxes etc., are the responsibility of others if applicable.

- Site security and patrol and site utilities, i.e., overhead electrical, potable and nonpotable process water, telephone, sanitary sewer or equivalent, and noncontaminated solid waste collection and disposal are provided by others.

- HEPA filter testing, and delivery to the project site are the responsibility of others.

- Site engineering surveys and waste location surveys if required are the responsibility of others.

- Costs associated with U.S. Department of Energy and/or Maintenance and Operations or Construction management and oversight are not included in this estimate.

- Administration, engineering, health physics, quality, training, safety, operations and associated records will be transmitted to applicable contractor offices and will be the responsibility of others.

- General site operations facilities and services will be available for project staff at nominal cost including but not limited to, general site training, specific craft training, radiological and hazardous materials training, fire/patrol support and control, and physical examinations.

- At the completion of project operations, jet grouting injection and support structures will be dismantled and staged, administrative and maintenance structures will be cleaned,/isolated/winterized, and equipment will be winterized and staged on site. These facilities/equipment/materials/etc. will be the property of the government.

- All equipment and materials are free on board INEEL.

- Dosimetry/dosimetry records, medical, testing and certification/medical records and associated programs are the responsibility of others.

- Safety analysis reports/reviews will be completed by others prior to contract award.

- Administrative, industrial safety and health, radiological control, quality, operations, etc., programs and plans be sued by the maintenance and operations site contractor will be adopted and approved prior to contract award.

- Engineering design of building structures and support structures/gantry systems will be the responsibility of others.

Equipment/Materials	Cost (each)	Quantity	X,Y,Z Gantry	Cover Block
PPE, Control System	$850,000		$850,000	$850,000
Mobilization/Site set up	NA		NA	NA
Aggregate (parking lot, roads, etc.)			$360,000	$360,000
Office trailers		5	$225,900	$225,900
Signs	$10,000		$10,000	$10,000
Storage boxes	$5,000		$20,000	$20,000
Pit building foundation	$8,700	11	$95,700	$95,700
140 x 400-ft structure (shipping/insulate) 2 bldgs moved 4 times each		2	$2,620,000	$2,620,000
Light plant (ea) interior lighting	$7,000	6	$42,000	$42,000
Liner (140 x 400 ft)	$160,000	11	$1,760,000	
TV 4-camera system (50K camera system; cd disc per year for 10 years)		2	$280,000	$280,000
Structure (24 x 50) equipment, mainteNANce etc.	$45,000	1	$45,000	$45,000
Structure (24 x 50) for grout plant and pump	$45,000	4	$180,000	$180,000
Ventilation/heat system for structure includes propane heat system w/15K gal tank; vaporating cooling system; HEPA filters; spare parts; moved 8 times; 5-year life cycle (systems required over lifetime of project)		1	$3,500,000	$3,500,000
480 Volt Generator 200 kw	$38,000	6	$228,000	$228,000
Drill shrouds 300 holes per shroud; 30 holes per shift	$15,000	80		$1,200,000
Cover Blocks (11 acres)	$25,800,000	Per acre		$283,800,000
Cover Block HEPA system		3 units		$145,000

Equipment/Materials	Cost (each)	Quantity	X,Y,Z Gantry	Cover Block
x,y,z gantry	$2,100,000	3	$6,300,000	
dry storage facility & supply system 2-550 ton silos & 3-30 ton silos (installed [10 days])	$691,000		$691,000	$691,000
C-8 trackdrill or equivalent w/Jean Lutz system radio controlled; each system to last 5 years; includes one backup	$346,000	6	$2,075,000	$2,075,000
Spare parts	$30,000	30	$900,000	$900,000
High pressure pump each system to last 5 years; includes one backup	$180,000	6	$1,080,000	$1,080,000
Pump spare parts (2000 hr kit)	$50,000	24	$1,200,000	$1,200,000
Grout Mixing plant (each system to last 5 years; includes one backup)	$75,000	6	$450,000	$450,000
480 volt generator 75kw	$20,500	6	$123,000	$123,000
Grout mixer spare parts (2000 hr kit)	$8,000	24	$192,000	$192,000
Polytank 10,000 gal	$12,000	2	$24,000	$24,000
Tractor	$91,500	4	$366,000	$366,000
dry product trailer	$105,000	3	$315,000	$315,000
MainteNAnce truck Ford 550 4x4 equipped (welder; misc tools)	$66,500	1	$66,500	$66,500
JLG Hili ft (80 ft) all-terrain	$120,000	2	$240,000	$240,000
All-terrain forklift (ea)	$100,000	1	$100,000	$100,000
Fuel truck 2000 gal	$100,000	1	$100,000	$100,000
40 ton hydro	$250,000	1	$250,000	$250,000
2-ton truck	$45,000	1	$45,000	$45,000
Pick-up truck	$35,000	4	$140,000	$140,000
Endloader	$320,000	1	$320,000	$320,000
10,000 gal water-wagon	$600,000	1	$600,000	$600,000

Equipment/Materials	Cost (each)	Quantity	X,Y,Z Gantry	Cover Block
Rock bed	$50,500	1	$50,500	$50,500
Quality Control on equipment	$200,000	NA	$200,000	$200,000
Equipment service (general maint.)	$400,000	NA	$400,000	$400,000
Fuel (6 gal/hr per generator; 15 gal/shift per rig)			$1,522,000	$1,522,000
24,000,000 gal grout dry materials (includes 20% waste)	$2.55/gal	24,000,000	$61,200,000	$61,200,000
Grout cap over treated pit 17 in. depth 7 ft soil cap not included	$354,000	10	$3,540,000	$3,540,000
Demobilization/Site Cleanup		NA		
Total			$92,706,600	$369,791,600
Consulting			$500,000	$500,000
Required training per person Initial	178,980.00	2355.00 pp for first year	$178,980	$178,980
Recertification cost per person per year	574,560.00	840.00 pp/py (9 years)	$574,560	$574,560
*76 employees at $137,500.00 per person; $104 Million over 10 years	$137,500	76	$104,000,000	$104,000,000
Subtotal			$197,960,140	$475,045,140
Performance bond	1.5%		$2,969,402	$7,125,677
Insurance	0.4%		$791,841	$1,900,181
Main office expense	3.9%		$7,720,445	$18,526,760
Profit	10.00%		$9,396,014	$37,100,000
Total			$218,837,842	$539,697,758
Total with—3% escalation 10 years			$251,663,518	$620,962,922

Personnel*

Exempt		Need
General Manager		1
Superintendent		2
Quality Control Administrator		1
Project Engineer/Assistant Superintendent		1
Administrative Assistant		2
Timekeeper/bookkeeper		1
Planner/scheduler		1
Safety Industrial Hygienist		2
Health Physics Supervisor		2
	1st shift personnel	9
	2nd shift personnel	4
		13
Building construction crew:		
General Foreman		1
Operator		1
Ironworker		6
Laborer		1
	1st shift personnel	9

Nonexempt		Need
General Foreman		1
Mechanics		2
Electricians		1
Instrument Technician		1
C-8 Operator		4
HP Pump Operator		2
Mixing Plant Operator		2
Equipment Operator	hydro, forklift, endloader	1
Teamster	fuel truck, h2o, 2 ton truck	3
Teamster	dry batch trucks, rock truck	3
Laborer	1 for PPE control	3
Radiological Technicians w/equipment		2
Relief Operator		2
	1st shift personnel	27
	2nd shift personnel	27
		54

*76 total at $137,500.00 per person; $104 million over 10 years.

Administrative				
Required training per person Initial		76	2355.00 pp for first year	178,980.00
Recertification cost per person per year		76	840.00 pp/py (9 years)	574,560.00
				753,540.00
		x,y	Cover block	
Performance bond	1.50%	3.5M	7.3M	
Insurance	0.04%	1M	1.9M	
Main office expense	3.90%	9M	19M	
Profit	10%	9.3M	34.5M	
Consulting				500,000.00

Appendix K

Thermocouple Data During Implementability Testing

Appendix K

Thermocouple Data During Implementability Testing

Table 1. Summary of thermocouple data for implementability testing.

	Year	Day	Hr/min	Panel temp	U.S. Grout	GMENT-12	TECT HG
101	2001	107	1640	26.14	23.58	32.27	25.66
101	2001	107	1700	24.41	25.35	32.97	23.92
101	2001	107	1720	23	23.89	33.39	22.58
101	2001	107	1740	23.01	24.6	33.88	23.75
101	2001	107	1800	22.96	21.29	34.46	23.18
101	2001	107	1820	21.9	20.33	34.99	21.21
101	2001	107	1840	21.09	22.57	35.7	20.22
101	2001	107	1900	20.65	30.11	36.5	19.89
101	2001	107	1920	20.3	30.88	37.46	19.59
101	2001	107	1940	19.53	31.55	38.46	18.7
101	2001	107	2000	18.63	32.13	39.41	17.71
101	2001	107	2020	17.82	32.67	40.24	16.84
101	2001	107	2040	17.07	33.23	40.98	16.04
101	2001	107	2100	16.36	33.82	41.66	15.3
101	2001	107	2120	15.81	34.39	42.31	14.76
101	2001	107	2140	15.29	34.96	42.97	14.25
101	2001	107	2200	14.78	35.51	43.66	13.73
101	2001	107	2220	14.27	36.07	44.41	13.2
101	2001	107	2240	13.85	36.62	45.23	12.8
101	2001	107	2300	13.53	37.2	46.13	12.53
101	2001	107	2320	13.29	37.81	47.1	12.35
101	2001	107	2340	13.12	38.45	48.15	12.24
101	2001	107	2400	13.03	39.11	49.24	12.25
101	2001	108	20	13.04	39.78	50.39	12.37
101	2001	108	40	13.13	40.48	51.6	12.61
101	2001	108	100	13.13	41.18	52.88	12.66
101	2001	108	120	13.03	41.86	54.21	12.55
101	2001	108	140	12.88	42.52	55.61	12.34
101	2001	108	200	12.73	43.12	57.07	12.17
101	2001	108	220	12.55	43.69	58.61	11.93
101	2001	108	240	12.37	44.21	60.2	11.73
101	2001	108	300	12.24	44.69	61.85	11.62
101	2001	108	320	12.08	45.14	63.53	11.44
101	2001	108	340	11.81	45.57	65.22	11.16
101	2001	108	400	11.5	45.95	66.91	10.86
101	2001	108	420	11.23	46.28	68.52	10.59
101	2001	108	440	11	46.57	70	10.34
101	2001	108	500	10.83	46.83	71.4	10.15
101	2001	108	520	10.68	47.06	72.5	10.01
101	2001	108	540	10.56	47.27	73.4	9.89
101	2001	108	600	10.44	47.45	74.2	9.79

101	2001	108	620	10.35	47.61	74.8	9.7
101	2001	108	640	10.25	47.74	75.3	9.61
101	2001	108	700	10.18	47.85	75.7	9.57
101	2001	108	720	10.13	47.95	76	9.54
101	2001	108	740	10.13	48.03	76.2	9.59
101	2001	108	800	10.19	48.08	76.4	9.69
101	2001	108	820	10.28	48.13	76.5	9.86
101	2001	108	840	10.4	48.16	76.6	10.06
101	2001	108	900	10.54	48.18	76.7	10.31
101	2001	108	920	10.69	48.19	76.8	10.56
101	2001	108	940	10.95	48.17	76.8	11.01
101	2001	108	1000	11.19	48.16	76.7	11.38
101	2001	108	1020	11.39	48.14	76.7	11.6
101	2001	108	1040	11.61	48.11	76.7	11.85
101	2001	108	1100	12.6	48.07	76.6	13.41
101	2001	108	1120	13.08	48.08	76.5	14.26
101	2001	108	1140	12.95	48.03	76.5	13.29
101	2001	108	1200	12.84	47.98	76.4	13
101	2001	108	1220	12.84	47.93	76.2	13.03
101	2001	108	1240	12.74	47.88	76.1	13.1
101	2001	108	1300	12.83	47.81	76	13.69
101	2001	108	1320	13.02	47.77	75.8	13.76
101	2001	108	1340	13.3	47.71	75.7	14.29
101	2001	108	1400	13.86	47.65	75.5	15.54
101	2001	108	1420	15.02	47.59	75.4	16.74
101	2001	108	1440	15.97	47.62	75.2	16.92
101	2001	108	1500	16.44	47.65	75.1	16.64
101	2001	108	1520	16.58	47.63	74.9	18.25
101	2001	108	1540	16.89	47.61	74.8	29.43
101	2001	108	1600	17.43	47.53	74.5	30.61
101	2001	108	1620	18.03	47.61	74.4	30.89
101	2001	108	1640	17.84	47.69	74.3	31.2
101	2001	108	1700	17.46	47.71	74.1	31.45
101	2001	108	1720	17.41	47.78	73.9	31.7
101	2001	108	1740	17.09	47.86	73.8	31.97
101	2001	108	1800	16.57	47.9	73.6	32.2
101	2001	108	1820	15.95	47.95	73.4	32.44
101	2001	108	1840	15.25	47.99	73.2	32.71
101	2001	108	1900	14.56	48.02	73	33.03
101	2001	108	1920	13.88	48.05	72.8	33.45
101	2001	108	1940	13.22	48.08	72.6	34.02
101	2001	108	2000	12.6	48.1	72.5	34.72
101	2001	108	2020	12.01	48.12	72.3	35.57
101	2001	108	2040	11.62	48.12	72.1	36.58
101	2001	108	2100	11.24	48.13	71.9	37.77
101	2001	108	2120	10.66	48.15	71.7	39.14
101	2001	108	2140	9.99	48.15	71.5	40.65
101	2001	108	2200	9.35	48.12	71.3	42.25
101	2001	108	2220	8.79	48.1	71.1	43.85

101	2001	108	2240	8.25	48.07	70.9	45.31
101	2001	108	2300	7.79	48.03	70.7	46.59
101	2001	108	2320	7.26	48	70.5	47.74
101	2001	108	2340	6.692	47.95	70.3	48.81
101	2001	108	2400	6.252	47.9	70.1	49.84
101	2001	109	20	5.853	47.83	69.95	50.88
101	2001	109	40	5.622	47.76	69.75	51.95
101	2001	109	100	5.452	47.69	69.55	53.02
101	2001	109	120	5.302	47.62	69.37	54.08
101	2001	109	140	5.174	47.56	69.19	55.13
101	2001	109	200	4.905	47.5	69.01	56.18
101	2001	109	220	4.71	47.43	68.83	57.22
101	2001	109	240	4.467	47.36	68.65	58.25
101	2001	109	300	4.181	47.28	68.47	59.27
101	2001	109	320	3.959	47.21	68.29	60.28
101	2001	109	340	3.833	47.12	68.11	61.28
101	2001	109	400	3.634	47.06	67.94	62.28
101	2001	109	420	3.393	46.98	67.77	63.3
101	2001	109	440	3.011	46.9	67.6	64.36
101	2001	109	500	2.717	46.82	67.43	65.45
101	2001	109	520	2.478	46.73	67.25	66.56
101	2001	109	540	2.263	46.64	67.07	67.65
101	2001	109	600	2.108	46.55	66.9	68.7
101	2001	109	620	1.931	46.47	66.74	69.66
101	2001	109	640	1.835	46.38	66.57	70.5
101	2001	109	700	1.915	46.31	66.41	71.2
101	2001	109	720	2.176	46.18	66.22	71.8
101	2001	109	740	3.158	46.01	65.98	72.3
101	2001	109	800	4.811	45.88	65.78	72.7
101	2001	109	820	6.094	45.85	65.65	73.1
101	2001	109	840	7.59	45.73	65.47	73.4
101	2001	109	900	8.86	45.67	65.33	73.6
101	2001	109	920	10.73	45.55	65.13	73.8
101	2001	109	940	12.96	45.51	64.99	74
101	2001	109	1000	14.75	45.5	64.88	74.1
101	2001	109	1020	16.18	45.44	64.75	74.3
101	2001	109	1040	17.94	45.37	64.61	74.3
101	2001	109	1100	19.55	45.36	64.52	74.4
101	2001	109	1120	20.2	45.31	64.41	74.5
101	2001	109	1140	21.21	45.2	64.24	74.5
101	2001	109	1200	23.09	45.1	64.06	74.4
101	2001	109	1220	24.98	45.02	63.91	74.4
101	2001	109	1240	26.84	45	63.81	74.4
101	2001	109	1300	27.8	44.89	63.64	74.4
101	2001	109	1320	29.28	44.86	63.54	74.3
101	2001	109	1340	30.58	44.86	63.46	74.3
101	2001	109	1400	30.15	44.73	63.29	74.2
101	2001	109	1420	30.79	44.73	63.22	74.2
101	2001	109	1440	31.06	44.55	63.01	74

101	2001	109	1500	32.32	44.43	62.85	73.9
101	2001	109	1520	32.79	44.39	62.74	73.8
101	2001	109	1540	33.15	44.36	62.64	73.7
101	2001	109	1600	31.89	44.31	62.54	73.6
101	2001	109	1620	31.93	44.04	62.28	73.4
101	2001	109	1640	31.87	44.06	62.23	73.4
101	2001	109	1700	28.82	44.18	62.22	73.3
101	2001	109	1720	25.61	44.03	62.06	73.2
101	2001	109	1740	24.42	43.75	61.8	72.9
101	2001	109	1800	24.12	43.64	61.65	72.8
101	2001	109	1820	23.32	43.62	61.55	72.6
101	2001	109	1840	21.89	43.57	61.44	72.5
101	2001	109	1900	20.45	43.48	61.31	72.3
101	2001	109	1920	19.18	43.4	61.18	72.2
101	2001	109	1940	17.7	43.33	61.06	72
101	2001	109	2000	16.11	43.25	60.95	71.9
101	2001	109	2020	14.68	43.16	60.81	71.7
101	2001	109	2040	13.53	43.06	60.67	71.5
101	2001	109	2100	12.49	42.97	60.53	71.4
101	2001	109	2120	11.49	42.89	60.4	71.2
101	2001	109	2140	10.64	42.79	60.25	71
101	2001	109	2200	9.95	42.69	60.11	70.8
101	2001	109	2220	9.44	42.6	59.96	70.6
101	2001	109	2240	8.87	42.52	59.84	70.5
101	2001	109	2300	8.32	42.43	59.71	70.3
101	2001	109	2320	7.82	42.35	59.58	70.1
101	2001	109	2340	7.38	42.26	59.45	69.92
101	2001	109	2400	6.848	42.19	59.34	69.75
101	2001	110	20	6.242	42.12	59.22	69.58
101	2001	110	40	5.813	42.01	59.07	69.38
101	2001	110	100	5.497	41.93	58.95	69.21
101	2001	110	120	5.121	41.87	58.84	69.04
101	2001	110	140	4.787	41.79	58.71	68.86
101	2001	110	200	4.548	41.71	58.59	68.68
101	2001	110	220	4.374	41.62	58.46	68.5
101	2001	110	240	4.35	41.53	58.33	68.32
101	2001	110	300	4.367	41.45	58.21	68.15
101	2001	110	320	4.278	41.39	58.1	67.99
101	2001	110	340	4.167	41.31	57.98	67.82
101	2001	110	400	4.008	41.24	57.87	67.65
101	2001	110	420	3.881	41.17	57.75	67.48
101	2001	110	440	3.798	41.09	57.64	67.31
101	2001	110	500	3.645	41.03	57.53	67.15
101	2001	110	520	3.38	40.98	57.43	66.99
101	2001	110	540	3.012	40.92	57.33	66.83
101	2001	110	600	2.635	40.85	57.21	66.65
101	2001	110	620	2.419	40.76	57.09	66.48
101	2001	110	640	2.399	40.67	56.97	66.31
101	2001	110	700	2.623	40.59	56.84	66.14

101	2001	110	720	3.051	40.51	56.72	65.97
101	2001	110	740	3.678	40.41	56.59	65.78
101	2001	110	800	4.432	40.32	56.46	65.61
101	2001	110	820	5.453	40.23	56.33	65.43
101	2001	110	840	6.564	40.18	56.23	65.27
101	2001	110	900	7.47	40.14	56.14	65.12
101	2001	110	920	8.19	40.1	56.04	64.94
101	2001	110	940	9.03	40.03	55.94	64.81
101	2001	110	1000	10.21	39.93	55.81	64.63
101	2001	110	1020	11.66	39.85	55.7	64.47
101	2001	110	1040	13.24	39.78	55.59	64.31
101	2001	110	1100	14.78	39.75	55.5	64.17
101	2001	110	1120	16.75	39.63	55.35	63.99
101	2001	110	1140	19.13	39.64	55.29	63.87
101	2001	110	1200	21.34	39.61	55.2	63.71
101	2001	110	1220	24.11	39.54	55.09	63.54
101	2001	110	1240	25.6	39.63	55.11	63.49
101	2001	110	1300	26.52	39.57	55.01	63.34
101	2001	110	1320	27.35	39.52	54.93	63.21
101	2001	110	1340	27.47	39.54	54.89	63.12
101	2001	110	1400	26.93	39.46	54.8	62.98
101	2001	110	1420	27.13	39.35	54.66	62.81
101	2001	110	1440	27.98	39.26	54.54	62.65
101	2001	110	1500	26.92	39.4	54.6	62.63
101	2001	110	1520	24.34	39.3	54.48	62.48
101	2001	110	1540	23.77	39.19	54.36	62.33
101	2001	110	1600	22.74	39.08	54.22	62.15
101	2001	110	1620	22.66	38.95	54.06	61.96
101	2001	110	1640	24.25	38.71	53.81	61.69
101	2001	110	1700	24.87	38.88	53.89	61.68
101	2001	110	1720	23.24	38.89	53.87	61.61
101	2001	110	1740	22.13	38.79	53.74	61.46
101	2001	110	1800	21.33	38.72	53.64	61.32
101	2001	110	1820	20.48	38.67	53.55	61.2
101	2001	110	1840	19.36	38.63	53.47	61.08
101	2001	110	1900	18.16	38.58	53.38	60.94
101	2001	110	1920	17.06	38.5	53.27	60.8
101	2001	110	1940	16.14	38.43	53.16	60.66
101	2001	110	2000	15.39	38.37	53.07	60.52
101	2001	110	2020	14.71	38.31	52.97	60.38
101	2001	110	2040	14.19	38.24	52.87	60.24
101	2001	110	2100	13.69	38.19	52.78	60.11
101	2001	110	2120	13.19	38.14	52.68	59.98
101	2001	110	2140	12.57	38.1	52.61	59.86
101	2001	110	2200	11.65	38.07	52.54	59.74
101	2001	110	2220	10.74	38.01	52.45	59.62
101	2001	110	2240	9.89	37.96	52.36	59.48
101	2001	110	2300	9.13	37.89	52.25	59.35
101	2001	110	2320	8.5	37.83	52.15	59.21

101	2001	110	2340	7.97	37.76	52.05	59.07
101	2001	110	2400	7.5	37.69	51.95	58.93
101	2001	111	20	7.11	37.62	51.85	58.8
101	2001	111	40	6.75	37.57	51.76	58.67
101	2001	111	100	6.303	37.54	51.68	58.55
101	2001	111	120	5.931	37.48	51.59	58.43
101	2001	111	140	5.646	37.41	51.49	58.3
101	2001	111	200	5.312	37.35	51.4	58.17
101	2001	111	220	4.97	37.3	51.3	58.05
101	2001	111	240	4.636	37.25	51.23	57.93
101	2001	111	300	4.209	37.21	51.15	57.82
101	2001	111	320	3.909	37.14	51.05	57.69
101	2001	111	340	3.87	37.06	50.94	57.55
101	2001	111	400	3.784	37.01	50.85	57.44
101	2001	111	420	3.659	36.95	50.76	57.32
101	2001	111	440	3.562	36.9	50.68	57.2
101	2001	111	500	3.372	36.86	50.6	57.09
101	2001	111	520	3.101	36.82	50.52	56.98
101	2001	111	540	2.945	36.76	50.42	56.85
101	2001	111	600	2.794	36.71	50.35	56.74
101	2001	111	620	2.56	36.66	50.26	56.63
101	2001	111	640	2.435	36.61	50.17	56.51
101	2001	111	700	2.382	36.55	50.08	56.39
101	2001	111	720	2.717	36.44	49.94	56.22
101	2001	111	740	3.845	36.33	49.8	56.06
101	2001	111	800	5.234	36.27	49.69	55.93
101	2001	111	820	6.553	36.22	49.61	55.82
101	2001	111	840	7.93	36.2	49.54	55.73
101	2001	111	900	9.32	36.18	49.48	55.64
101	2001	111	920	10.59	36.17	49.43	55.55
101	2001	111	940	11.94	36.15	49.36	55.45
101	2001	111	1000	13.54	36.11	49.28	55.34
101	2001	111	1020	15.03	36.1	49.22	55.24
101	2001	111	1040	16.39	36.07	49.16	55.15
101	2001	111	1100	17.78	36.03	49.09	55.04
101	2001	111	1120	19.26	35.97	49	54.93
101	2001	111	1140	20.99	35.95	48.93	54.82
101	2001	111	1200	22.58	35.95	48.88	54.75
101	2001	111	1220	24.35	35.91	48.8	54.65
101	2001	111	1240	25.79	35.92	48.75	54.57
101	2001	111	1300	27.46	35.87	48.67	54.46
101	2001	111	1320	28.84	35.85	48.6	54.37
101	2001	111	1340	30.24	35.77	48.49	54.24
101	2001	111	1400	31.22	35.75	48.43	54.15
101	2001	111	1420	31.57	35.69	48.35	54.05
101	2001	111	1440	32.64	35.69	48.31	53.98
101	2001	111	1500	32.47	35.71	48.29	53.93
101	2001	111	1520	32.34	35.59	48.16	53.77
101	2001	111	1540	32.53	35.55	48.09	53.69

101	2001	111	1600	32.88	35.47	47.99	53.57
101	2001	111	1620	31.52	35.66	48.09	53.62
101	2001	111	1640	28.85	35.61	48.02	53.54
101	2001	111	1700	26.51	35.57	47.98	53.48
101	2001	111	1720	24.31	35.51	47.89	53.38
101	2001	111	1740	22.23	35.45	47.81	53.28
101	2001	111	1800	20.34	35.39	47.72	53.16
101	2001	111	1820	19.13	35.28	47.59	53.01
101	2001	111	1840	18.82	35.18	47.47	52.88
101	2001	111	1900	18.36	35.16	47.4	52.79
101	2001	111	1920	17.2	35.17	47.38	52.73
101	2001	111	1940	16.1	35.1	47.29	52.62
101	2001	111	2000	15.19	35.07	47.21	52.53
101	2001	111	2020	14.28	35.04	47.14	52.44
101	2001	111	2040	13.52	34.98	47.05	52.34
101	2001	111	2100	12.73	34.96	46.98	52.26
101	2001	111	2120	11.94	34.9	46.9	52.15
101	2001	111	2140	11.3	34.87	46.82	52.06
101	2001	111	2200	10.48	34.83	46.76	51.97
101	2001	111	2220	9.81	34.79	46.68	51.88
101	2001	111	2240	9.08	34.76	46.62	51.79
101	2001	111	2300	8.37	34.73	46.55	51.7
101	2001	111	2320	7.72	34.67	46.46	51.6
101	2001	111	2340	7.33	34.59	46.36	51.49
101	2001	111	2400	6.99	34.54	46.28	51.39
101	2001	112	20	6.6	34.52	46.22	51.31
101	2001	112	40	6.302	34.47	46.14	51.21
101	2001	112	100	6.026	34.44	46.07	51.12
101	2001	112	120	5.702	34.39	45.99	51.03
101	2001	112	140	5.561	34.34	45.91	50.93
101	2001	112	200	5.508	34.29	45.83	50.83
101	2001	112	220	5.532	34.24	45.75	50.74
101	2001	112	240	5.474	34.21	45.68	50.66
101	2001	112	300	5.367	34.16	45.61	50.56
101	2001	112	320	5.522	34.11	45.53	50.47
101	2001	112	340	5.916	34.06	45.45	50.37
101	2001	112	400	6.269	34.04	45.39	50.29
101	2001	112	420	6.388	34.05	45.35	50.23
101	2001	112	440	6.017	34.08	45.33	50.18
101	2001	112	500	5.517	34.02	45.25	50.09
101	2001	112	520	5.07	33.98	45.18	50.01
101	2001	112	540	4.502	33.96	45.12	49.93
101	2001	112	600	4.024	33.9	45.05	49.84
101	2001	112	620	3.926	33.85	44.96	49.74
101	2001	112	640	3.867	33.79	44.88	49.64
101	2001	112	700	4.133	33.74	44.79	49.55
101	2001	112	720	4.792	33.63	44.66	49.41
101	2001	112	740	5.87	33.57	44.57	49.3
101	2001	112	800	6.708	33.53	44.49	49.21

101	2001	112	820	7.82	33.49	44.41	49.11
101	2001	112	840	9.11	33.45	44.34	49.02
101	2001	112	900	10.24	33.43	44.29	48.95
101	2001	112	920	11.52	33.38	44.22	48.85
101	2001	112	940	13.02	33.36	44.16	48.76
101	2001	112	1000	14.49	33.34	44.1	48.69
101	2001	112	1020	15.86	33.36	44.07	48.64
101	2001	112	1040	17.26	33.32	44	48.56
101	2001	112	1100	18.09	33.36	43.99	48.53
101	2001	112	1120	18.69	33.29	43.9	48.44
101	2001	112	1140	19.81	33.22	43.8	48.33
101	2001	112	1200	21.24	33.21	43.75	48.25
101	2001	112	1220	22.61	33.25	43.74	48.22
101	2001	112	1240	23.88	33.21	43.67	48.14
101	2001	112	1300	25.18	33.23	43.65	48.09
101	2001	112	1320	26.44	33.18	43.56	47.99
101	2001	112	1340	27.4	33.14	43.5	47.91
101	2001	112	1400	28.43	33.19	43.51	47.9
101	2001	112	1420	28.24	33.26	43.54	47.9
101	2001	112	1440	27.53	33.19	43.45	47.81
101	2001	112	1500	27.18	33.16	43.4	47.75
101	2001	112	1520	26.92	33.1	43.31	47.65
101	2001	112	1540	25.8	33.15	43.32	47.65
101	2001	112	1600	23.9	33.1	43.26	47.58
101	2001	112	1620	23.05	32.99	43.17	47.49
101	2001	112	1640	22.21	32.93	43.12	47.43
101	2001	112	1700	21.45	32.94	43.05	47.34
101	2001	112	1720	21.18	32.87	42.95	47.24
101	2001	112	1740	21.07	32.86	42.89	47.16
101	2001	112	1800	20.62	32.85	42.84	47.1
101	2001	112	1820	19.85	32.84	42.82	47.07
101	2001	112	1840	18.63	32.84	42.79	47.03
101	2001	112	1900	17.34	32.81	42.74	46.97
101	2001	112	1920	16.31	32.75	42.66	46.88
101	2001	112	1940	15.38	32.72	42.6	46.8
101	2001	112	2000	14.39	32.7	42.54	46.73
101	2001	112	2020	13.45	32.67	42.48	46.65
101	2001	112	2040	12.69	32.63	42.41	46.56
101	2001	112	2100	12.09	32.59	42.35	46.49
101	2001	112	2120	11.58	32.53	42.27	46.41
101	2001	112	2140	11.07	32.5	42.21	46.34
101	2001	112	2200	10.61	32.46	42.14	46.26
101	2001	112	2220	10.29	32.42	42.07	46.18
101	2001	112	2240	10.03	32.39	42.01	46.11
101	2001	112	2300	9.75	32.36	41.95	46.04
101	2001	112	2320	9.44	32.34	41.89	45.98
101	2001	112	2340	9.15	32.32	41.84	45.9
101	2001	112	2400	8.91	32.29	41.78	45.83
101	2001	113	20	8.7	32.26	41.72	45.76

101	2001	113	40	8.4	32.25	41.67	45.7
101	2001	113	100	7.95	32.24	41.63	45.65
101	2001	113	120	7.62	32.2	41.56	45.58
101	2001	113	140	7.26	32.19	41.52	45.52
101	2001	113	200	6.939	32.15	41.45	45.44
101	2001	113	220	6.768	32.08	41.36	45.35
101	2001	113	240	6.851	32.03	41.29	45.27
101	2001	113	300	7.05	32	41.23	45.2
101	2001	113	320	7.16	31.98	41.18	45.14
101	2001	113	340	7.28	31.96	41.13	45.08
101	2001	113	400	7.16	31.95	41.09	45.03
101	2001	113	420	7.03	31.91	41.02	44.95
101	2001	113	440	7.09	31.88	40.96	44.88
101	2001	113	500	7.16	31.85	40.91	44.81
101	2001	113	520	7.28	31.83	40.86	44.75
101	2001	113	540	7.3	31.81	40.81	44.69
101	2001	113	600	7.31	31.78	40.76	44.63
101	2001	113	620	7.27	31.76	40.71	44.57
101	2001	113	640	7.32	31.72	40.65	44.49
101	2001	113	700	7.53	31.69	40.58	44.42
101	2001	113	720	7.93	31.65	40.52	44.35
101	2001	113	740	8.56	31.6	40.45	44.25
101	2001	113	800	9.39	31.58	40.4	44.19
101	2001	113	820	10.26			
101	2001	113	840	11.85			
101	2001	113	900	15.42			
101	2001	113	920	17.21			
101	2001	113	940	18.11			
101	2001	113	1000	18.71			
101	2001	113	1020	19.15			
101	2001	113	1040	19.47			
101	2001	113	1100	19.71			
101	2001	113	1120	19.93			
101	2001	113	1140	20.07			
101	2001	113	1200	20.11			
101	2001	113	1220	20.15			
101	2001	113	1240	20.17			
101	2001	113	1300	20.18			
101	2001	113	1320	20.19			
101	2001	113	1340	20.21			
101	2001	113	1400	20.24			
101	2001	113	1420	20.28			
101	2001	113	1440	20.31			
101	2001	113	1500	20.35			
101	2001	113	1520	20.39			
101	2001	113	1540	20.43			
101	2001	113	1600	20.46			
101	2001	113	1620	20.5			
101	2001	113	1640	20.54			

101	2001	113	1700	20.58
101	2001	113	1720	20.62
101	2001	113	1740	20.7
101	2001	113	1800	20.8
101	2001	113	1820	20.84
101	2001	113	1840	20.86
101	2001	113	1900	20.85
101	2001	113	1920	20.83
101	2001	113	1940	20.82
101	2001	113	2000	20.79
101	2001	113	2020	20.77
101	2001	113	2040	20.75
101	2001	113	2100	20.72
101	2001	113	2120	20.69
101	2001	113	2140	20.66
101	2001	113	2200	20.63
101	2001	113	2220	20.59
101	2001	113	2240	20.56
101	2001	113	2300	20.52
101	2001	113	2320	20.48
101	2001	113	2340	20.44
101	2001	113	2400	20.4
101	2001	114	20	20.35
101	2001	114	40	20.31
101	2001	114	100	20.27
101	2001	114	120	20.24
101	2001	114	140	20.22
101	2001	114	200	20.18
101	2001	114	220	20.15
101	2001	114	240	20.12
101	2001	114	300	20.08
101	2001	114	320	20.05
101	2001	114	340	20.05
101	2001	114	400	20.08
101	2001	114	420	20.05
101	2001	114	440	20.03
101	2001	114	500	20.08
101	2001	114	520	20.05
101	2001	114	540	20
101	2001	114	600	19.96
101	2001	114	620	19.98
101	2001	114	640	19.96
101	2001	114	700	19.9
101	2001	114	720	19.88
101	2001	114	740	19.97
101	2001	114	800	20.14
101	2001	116	1320	21.9

Appendix L

Inductively Coupled Plasma-Mass Spectroscopy Evaluation of Smears and Air-Filter Samples

Appendix L

Inductively Coupled Plasma-Mass Spectroscopy Evaluation of Smears and Air-Filter Samples

Discussed in this appendix are details of sample preparation and sample evaluation using inductively coupled plasma-mass spectroscopy (ICP-MS).

Dissolution Procedure for Smears

Reagents and standards:

- 50% nitric acid solution
- Surrogate spiking solution. 1,000 ppm Ho and Pr * 2.5 mL /100 mL = 25 ppm Ho, Pr (2.5% HNO3)
- LCS Spiking Solution. 1,000 ppm terbium * 1.0 mL/100 mL = 10 ppm terbium
- 30% hydrogen peroxide solution.

The smears were weighed and placed into a Teflon beaker. A 0.5-mL aliquot of the surrogate spiking solution was added to each beaker and allowed to dry. 10 mL of the 50% HNO_3 solution was added to each beaker, and a Teflon watch glass was placed on top. The samples were refluxed for ~1 hour, removed from the heat and cooled. Approximately 3 mL of the 30% H_2O_2 solution was added to each beaker, the beaker covered, and then heated for ~1 hour. 3 mL more of the 30% H_2O_2 was added and the sample reheated again. The samples were then cooled, filtered samples into 50-mL volumetric flasks, diluted to volume. Prep blanks, prep blank filters and prep spike filters were also processed along with the smears. Samples were diluted 1/10 before analysis. An internal standard (100 ppb indium) was added to each sample before analysis.

Dissolution Procedure for Filters

Reagents and standards:

- 50% nitric acid solution
- Surrogate Spiking Solution. 1,000 ppm holmium and praseodymium * 2.5 mL /100 mL = 25 ppm holmium, praseodymium (2.5% HNO_3)
- LCS Spiking Solution. 1,000 ppm terbium * 1.0 mL/100 mL = 10 ppm terbium
- 30% hydrofluoric acid solution.

Seven large rectangle filters from an air sampler had previously been combined together as a single sample and placed in a bag. An 8-cm-diameter circle was cut from the center of the stack of filters. The circles were weighed and placed into a Teflon beaker. A 0.5-mL aliquot of the surrogate spiking solution was added to each sample and allowed to dry. 50 mL of the HF solution was added to each beaker, the beaker covered and heated for about 2 hours. After dissolving the glass fiber filter material, the cover was

removed and the sample allowed to evaporate to near dryness. The sample was then removed from the heat and cooled. 10 mL of the HNO_3 solution was added, the sample covered and heated for ~1 hour. The samples were then cooled, filtered into a 50-mL volumetric flask and diluted to volume. Duplicate samples for some samples were cut from the filters and processed along with the rest of the samples.

Sample Results

Results from all of the samples are listed below. Overall, the results for the smears are quite reasonable relative to the sample blanks and spikes. In an attempt to get the best detection limits for the filters, the analyst opted to use only a 1:100 dilution of the sample digest. As noted in the In recovery and the variations in the Ho and Pr, this may have caused some error in the terbium numbers, however the sample spikes seem reasonable. The extremely high concentration of other elements in the sample matrix (most notably Ba) caused some degradation in instrument performance during the filter runs because of buildup on the sampling cones and lens stack of the ICP-MS. Dilution factors of 1,000+ would probably have alleviated this problem as it did with the smears. The results with the blank filters at 1:500 dilutions were comparable to the actual samples at the 1:100 dilutions, leading to the conclusion that the filtered did not collect any measurable quantities of terbium-contaminated dirt.

	Pr 141 ng/mL	Tb 159 ng/mL	Ho 165 ng/mL	In 115 % recovery	Sample Mass (gms)	Dilution Factor	ng/smear or ng/sample	Area (cm^2)	Total Tb (ng)	ng Tb/cm^2	ng Tb/g
ISG20401fw-smear 1/10	23.957	0.007	24.058	79.7	0.1166	500.0	< 11.8				
ISG20501fw-smear 1/10	25.424	0.005	25.451	79.5	0.1138	500.0	< 11.8				
ISG20601fw-smear 1/10	24.320	0.044	24.371	79.3	0.1146	500.0	21.8				
ISG24101fw-smear 1/10	25.888	0.033	25.909	75.4	0.1211	500.0	16.3				
ISG24201fw-smear 1/10	25.671	0.019	25.806	76.8	0.1224	500.0	< 11.8				
ISG24301fw-smear 1/10	26.063	0.014	26.223	77.6	0.1228	500.0	< 11.8				
ISG24401fw-smear 1/10	26.179	0.006	26.051	88.7	0.1201	500.0	< 11.8				
ISG24401fw-smear spk 1/10	26.128	27.408	25.773	89.2		500.0					
true spk		25.000									
% recovery		109.6									
ISG24501fw-smear 1/10	24.598	0.070	24.200	83.6	0.1179	500.0	35.2				
ISG24501fw-smear spk 1/10	26.359	27.781	26.088	89.6		500.0					
true spk		25.000									
% recovery		110.8									
ISG24601fw-smear 1/10	24.641	0.011	24.494	79.9	0.1188	500.0	< 11.8				
ISG24701fw-smear 1/10	24.874	0.028	24.696	78.8	0.1230	500.0	14.2				
ISG27901fw-smear 1/10	25.425	0.003	25.673	78.2	0.1140	500.0	< 11.8				
ISG28001fw-smear 1/10	24.599	-0.003	24.946	85.8	0.1145	500.0	< 11.8				
ISG28101fw-smear 1/10	26.116	-0.001	26.651	82.0	0.1122	500.0	< 11.8				
ISG28401fw-smear 1/10	25.920	0.004	25.843	93.3	0.1179	500.0	< 11.8				
ISG28501fw-smear 1/10	27.179	0.021	27.200	82.0	0.1236	500.0	< 11.8				
ISG28601fw-smear 1/10	24.384	0.024	23.926	88.3	0.1252	500.0	12.2				
ISG28701fw-smear 1/10	25.893	0.011	25.633	88.3	0.1296	500.0	< 11.8				
ISG28701fw-smear dup 1/10	26.736	0.014	26.823	79.1		500.0	< 11.8				
avg		0.013									
ISG28801fw-smear 1/10	26.544	0.056	25.997	88.0	0.1317	500.0	28.0				
ISG28901fw-smear 1/10	25.177	0.003	25.324	76.8	0.1175	500.0	< 11.8				
ISG28901fw-smear dup	25.879	0.064	25.747	92.1		500.0	32.2				

Table. (continued.)

	Pr 141 ng/mL	Tb 159 ng/mL	Ho 165 ng/mL	In 115 % recovery	Sample Mass (gms)	Dilution Factor	ng/smear or ng/sample	Area (cm^2)	Total Tb (ng)	ng Tb/cm^2	ng Tb/g
1/10											
avg		0.034					32.2				
ISG29001fw-smear 1/10	25.910	0.003	25.861	76.6	0.1143	500.0	< 11.8				
ISG34701fw-H2O 1/10	26.842	0.088	24.354	87.1	100 mL	1000.0	87.8				
ISG34701fw-H2O spk 1/10	26.347	25.280	23.655	89.3		500.0	12639.9				
true spk		25.000									
% recovery		100.8									
ISG52601fw-smear 1/10	26.377	0.043	25.428	92.9	0.1300	500.0	21.5				
ISG55001fw-smear 1/10	25.859	0.002	25.781	91.7	0.1180	500.0	< 11.8				
ISG55001fw-smear dup 1/10	26.329	0.010	26.398	89.7		500.0	< 11.8				
avg		0.006									
ISG55101fw-smear 1/10	26.054	0.001	26.514	83.0	0.1152	500.0	< 11.8				
ISG55201fw-smear 1/10	26.212	0.000	26.437	87.1	0.1126	500.0	< 11.8				
ISG55301fw-smear 1/10	25.599	0.017	25.518	76.8	0.1235	500.0	< 11.8				
ISG55401fw-smear 1/10	24.864	0.004	25.009	77.8	0.1983	500.0	< 11.8				
ISG62501fw-smear 1/10	25.902	-0.001	26.131	89.8	0.1169	500.0	< 11.8				
ISG62601fw-smear 1/10	26.109	-0.001	26.098	91.6	0.1120	500.0	< 11.8				
ISG62701fw-smear 1/10	24.402	-0.002	24.463	92.9	0.1149	500.0	< 11.8				
QC - 0 ng/mL - mean	0.000	0.000	0.000	89.5							
QC - 0 ng/mL - Stdev	0.021	0.008	0.008	11.0							
QC - 100 ng/mL - mean	106.241	105.093	103.001	88.0							
QC - 100 ng/mL - stdev	2.348	2.744	2.261	10.5							
QC - 100 ng/mL - % error	6.2	5.1	3.0								
Prep Blk filter spk #1 1/10	26.859	10.850	26.872	86.8							
true spk		10.000									

Table. (continued.)

	Pr 141 ng/mL	Tb 159 ng/mL	Ho 165 ng/mL	In 115 % recovery	Sample Mass (gms)	Dilution Factor	ng/smear or ng/sample	Area (cm^2)	Total Tb (ng)	ng Tb/cm^2	ng Tb/g
% recovery		108.5									
Prep Blk filter spk #2 1/10	27.047	11.038	27.069	88.2							
true spk		10.000									
% recovery		110.4									
LCS Spk #1 1/10	25.701	2.044	25.310	89.1							
true spk		2.000									
% recovery		102.2									
LCS Spk #2 1/10	26.084	2.099	25.726	87.7							
true spk		2.000									
% recovery		104.9									
Prep blk #1 1/10	26.805	-0.004	27.480	80.7							
Prep blk #2 1/10	25.697	-0.003	26.235	86.4							
Prep blk #3 1/10	25.769	-0.004	26.104	88.1							
Prep blk filter #1 1/10	27.132	0.000	27.283	79.0							
Prep blk filter #2 1/10	26.183	-0.002	26.208	84.3							
smear blk 1	21.468	0.010	23.273	72.3	0.1128	500.0	5.2				
smear blk 2	20.838	0.008	22.483	73.8	0.1175	500.0	< 4.6				
smear blk 3	21.048	0.004	22.493	76.5	0.1195	500.0	< 4.6				
smear blk 4	21.568	0.004	22.893	79.4	0.1187	500.0	< 4.6				
smear blk 5	20.828	0.006	22.143	80.6	0.1200	500.0	< 4.6				
smear blk 6	21.068	0.003	22.513	81.8	0.1221	500.0	< 4.6				
smear blk 6 spk	113.078	99.276	122.713	84.8	0.1221						
true spike	100.000	100.000	100.000								
% recovery	92.010	99.273	100.200								
Blank Smear Mass - Mean					0.1190						
Blank Smear Mass - Stdev					0.0032						
QC - 0 ng/mL - mean	0.000	0.000	0.000	75.5							

Table. (continued.)

	Pr 141 ng/mL	Tb 159 ng/mL	Ho 165 ng/mL	In 115 % recovery	Sample Mass (gms)	Dilution Factor	ng/smear or ng/sample	Area (cm^2)	Total Tb (ng)	ng Tb/cm^2	ng Tb/g
QC - 0 ng/mL - Stdev	0.004	0.003	0.003	21.6							
QC - 100 ng/mL - mean	104.028	104.626	103.363	59.1							
QC - 100 ng/mL - stdev	0.919	1.626	1.344	4.2							
QC - 100 ng/mL - % error	4.0	4.6	3.4								
filter blk 1	25.958	1.168	16.393	51.7	2.8450	500	584.2	351.9	584.2	1.7	205.3
filter blk 2	19.618	0.829	10.813	52.9	2.8598	500	414.7	351.9	414.7	1.2	145.0
filter blk 2 spk	108.478	90.986	99.213	52.3							
true spike	100	100	100								
% recovery	88.9	90.2	88.4								
Filter blank - mean					2.8524						175.2
Filter blank - Relative % Difference (RPD)					0.52						34.4
ISG22201fw-filter 1/2	178.551	7.328	70.704	33.3	3.1375	100.0	732.8	351.9	732.8	2.1	233.6
ISG22301fw-filter 1/2	194.851	7.469	71.784	36.7	3.4266	100.0	746.9	351.9	746.9	2.1	218.0
ISG22401fw-filter 1/2	174.251	5.670	78.904	31.2	2.9681	100.0	567.0	351.9	567.0	1.6	191.0
ISG23101fw-filter 1/2	167.051	5.033	92.544	47.8	2.8540	100.0	503.3	351.9	503.3	1.4	176.4
ISG23101fw-filter 1/2 spk	163.451	13.701	84.904	54.7	2.8501	100.0	1370.1	351.9	1370.1	3.9	480.7
true spk		12.5									
% recovery		69.3					69.3				
ISG23201fw-filter 1/2	168.351	4.917	82.194	49.4	2.8560	100.0	491.7	351.9	491.7	1.4	172.2
ISG23301fw-filter 1/2	111.351	3.980	72.074	95.1	2.8864	100.0	398.0	351.9	398.0	1.1	137.9
ISG23401fw-filter 1/2	151.651	4.984	85.864	93.2	2.8868	100.0	498.4	351.9	498.4	1.4	172.7
ISG23501fw-filter 1/2	143.351	3.929	59.814	90.5	2.8638	100.0	392.9	351.9	392.9	1.1	137.2
ISG23501fw-filter 1/2 dup	161.551	5.270	77.274	80.0	2.9050	100.0	527.0	351.9	527.0	1.5	181.4
ISG23601fw-filter 1/2	171.951	5.784	88.544	70.6	2.9321	100.0	578.4	351.9	578.4	1.6	197.3
ISG23701fw-filter 1/2	83.231	2.549	51.514	80.0	2.9534	100.0	254.9	351.9	254.9	0.7	86.3
ISG23801fw-filter 1/2	133.451	3.815	71.644	66.7	2.8851	100.0	381.5	351.9	381.5	1.1	132.2

Table. (continued.)

	Pr 141 ng/mL	Tb 159 ng/mL	Ho 165 ng/mL	In 115 % recovery	Sample Mass (gms)	Dilution Factor	ng/smear or ng/sample	Area (cm^2)	Total Tb (ng)	ng Tb/cm^2	ng Tb/g
ISG23901fw-filter 1/2	176.751	5.834	77.854	55.8	3.1029	100.0	583.4	351.9	583.4	1.7	188.0
ISG24001fw-filter 1/2	174.351	5.565	88.294	50.3	2.8640	100.0	556.5	351.9	556.5	1.6	194.3
ISG50001fw-filter 1/2	177.551	5.173	84.864	44.2	2.8207	100.0	517.3	351.9	517.3	1.5	183.4
ISG50101fw-filter 1/2	155.151	4.803	100.614	45.4	2.8248	100.0	480.3	351.9	480.3	1.4	170.0
ISG50101fw-filter 1/2 dup	163.151	4.689	81.054	41.4	2.8467	100.0	468.9	351.9	468.9	1.3	164.7
ISG50201fw-filter 1/2	181.851	5.513	91.464	38.3	2.8628	100.0	551.3	351.9	551.3	1.6	192.6
ISG50301fw-filter 1/2	177.051	4.780	74.834	35.4	2.8044	100.0	478.0	351.9	478.0	1.4	170.5
ISG50301fw-filter 1/2 spk	195.251	16.651	99.044	31.5	2.7907	100.0	1665.1	351.9	1665.1	4.7	596.7
true spk		12.5									
% recovery		95.0					95.0				
ISG50401fw-filter 1/2	169.051	5.381	73.944	34.5	3.0092	100.0	538.1	351.9	538.1	1.5	178.8
QC - 0 ng/mL - mean	0.000	0.000	0.000	75.9							
QC - 0 ng/mL - Stdev	0.010	0.001	0.005	19.7							
QC - 100 ng/mL - mean	112.734	102.220	98.935	74.4							
QC - 100 ng/mL - stdev	4.792	2.088	1.822	18.1							
QC - 100 ng/mL - % error	12.7	2.2	-1.1								